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COMPUTER EVALUATION OF LANGUAGE SKILLS IN CHILDREN

D.E. PRESSMAN, S.J. CUNNINGHAM, I.S. PRESSMAN, J.W. BRAHAN, AND W.H. HENNEKER

DECEMBER 1982

Canada

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ABSTRACT

This report describes the application of computer technology to the testing of language and learning disabled children. An adaptation of the Goldman-Fristoe-Woodcock Auditory Skills Test Battery was selected as the basis of an automated assessment procedure. Computer-administered testing courseware based upon this procedure was prepared in the NATAL programming language and delivered to the child on a Lektromedia 421 Portable Learning Assessment Terminal consisting of an random access tape recorder and slide projector with accompanying touch sensitive screen. The automated version of this procedure may be administered by a technician or volunteer for subsequent interpretation by health care professionals. Output from the computerized procedure includes several reports on a child's progress through the battery of tests.

RÉSUMÉ

Le présent rapport décrit l'application de méthodes informatiques pour tester les enfants ayant des difficultés d'apprentissage. On a sélectionné une adaptation de la batterie de tests de capacité auditive de Goldman-Fristoe-Woodcock comme base d'une méthode d'évaluation automatisée. Du matériel de test, présenté par un ordinateur, a été préparé en langage de programmation NATAL et soumis aux enfants sur un terminal portatif d'évaluation de l'apprentissage Lektromedia 421. L'ensemble était constitué d'un magnétophone à accès aléatoire, d'un projecteur de diapositives et d'un ecran cathodique sensible au toucher. La version ainsi automatisée permet à des techniciens ou des volontaires de faire passer les tests aux enfants, les résultats étant ensuite analysés par des spécialistes. La procédure informatisée comprend la production de rapports sur les progrès de l'enfant au cours de la batterie de tests.

COMPUTER EVALUATION OF LANGUAGE SKILLS IN CHILDREN

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J.W. Braham and W.H. Henneker

CHAPTER 1

INTRODUCTION

Advances in computer technology in the areas of hardware and software have enhanced the possible role of the computer in the clinical practice of many allied health disciplines. High level computer languages such as APL, NATAL or PASCAL together with the new generation of computers permit rapid, efficient presentations of complex tasks. Items may be presented in complex combinations of audio and video and/or in random order when required. Data can be stored and retrieved in efficient ways. These data can be formulated in clinically acceptable and palatable reports.

These characteristics are available in some computer systems currently available. Continuing developments in hardware and software such as the system described in this manual will further enhance the application of computer technology to clinical settings. The professional has every reason to anticipate that this technology will play a significant role in the future of the health professions.

Computers and computer-assisted applications in the health care field should be utilized to impact positively on the limited human resources available in many patient care clinics today. The computer has proved to be a valuable resource in industry and it can be adapted to the clinical scene to enable the professional to undertake tasks which are currently not time efficient.

Repetitive tasks, those requiring routine responses to easily sequenced stimuli, and programmed learning activities can be administered under computer control with success. In fact, computers can administer some clinical tests and provide greater control, objectivity and scientific scrutiny than standard human-administered clinical assessment procedures. They can simplify data collection, tabulation and analysis. They cannot replace human judgement, clinical discretion and a human relationship with the client.

Computer applications, including the applications discussed here, can be designed to be an asset to the professional. It is

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imperative that such systems are not used to dehumanize clinical contact but rather to improve access to some specific clinical services for which they are well designed.

All computerized systems functioning in a clinical context should be supervised by the practising professional. Human perception, sensitivity, clinical judgement and clinical artistry cannot be replaced by machine technology, no matter how well developed. The Speech-Language Pathologist and other health and education practitioners must be cognizant of the usefulness of the computer as a new and powerful tool in the practice of these professions.

Background Information

The use of the computer as a tool for assessment purposes in health and education is a logical outgrowth of the current computer technology. Computers are being used for scoring detailed test results and for automatic diagnostic purposes (1, 2). Computer-administered assessment procedures have proved efficient and cost effective for psychiatric diagnosis (3, 4) and for comprehensive behavioural assessment (5). These developments have led to recent concern for staff acceptance of computers and to studies indicating appropriate methods for preparing clinicians for the use of automated procedures (6).

Computer development in the field of language has been diverted towards analysis of test results. Anderson (7) outlined the development of computer techniques for diagnostic analysis of the test results of children with learning disabilities. Somers (8) described a computer package for automatically analyzing the results of articulation tests. These programs are computer-aided in terms of the analysis of test scores, but testing is administered in the standard fashion.

Many computer-assisted testing procedures have been developed, especially for adults. There are also some studies involving computers and children which report real advantages of computer test administration.

A computer-administered verson of the Peabody Picture Vocabulary Test (9) was found to be as valid and reliable as the standard administration when used with institutionalized retarded children (10). These children interacted well with the terminal and there were no significant differences in test results between the methods of presentation. Various other investigators have reported success with computer-assisted testing with children in the areas of mathematics, reading and general achievement (11-14).

Johnson and Mihal (15) demonstrated that black students in grades seven and eight obtained higher scores on a college ability test with computer administration than with standard administration. It was concluded that the automated version did not activate the anxiety which

occurs when tests are administered by testers from more advantaged backgrounds. In conjunction with the National Research Council and the Children's Hospital of Eastern Ontario, the Computer Assisted Learning Laboratory at Carleton University has been involved in development and evaluation of computer-aided testing for a number of years. Automated versions of the Continuous Performance Test of Attention (16), The Peabody Picture Vocabulary Test (9), The Coloured Progressive Matrices Test (17) and the Reitan Indiana Category Test (18) have been compared with the standard versions in administrations to retarded, disadvantaged and normal youngsters. Computer-assisted administration was found to be feasible and reliable and the children appeared to enjoy interacting with the terminal (19). Knights et al. (20) have also developed a battery of achievement tests for children from grades three to eight and an automated paediatric history-taking questionnaire. These automated assessments have proved useful and efficient in paediatric clinic applications. A diagnostic assesssment of basic reading skills has also been designed, and extensive normative data collected (21). This program is administered with the help of a tester to determine a child's strengths and weaknesses in skills basic to the learning-to-read process and provides a profile of his performance and suggestions for subsequent training. Such procedures, designed as screening devices, may be administered by a relatively untrained person. The computer software substitutes for the professionally trained individual. With such automated procedures, basic tests can be administered to more children with less professional involvement. The highly trained clinician has test results available when the child is seen. More time is made avalable for detailed diagnostic assessments and recommendations for training (22).

The use of the computer as a screening tool is one of the major advantages indicated by these studies. The fact that assessments may be administered by a relatively untrained tester is cost effective and efficient. The use of the computer also permits standardization of the testing situation and manner of presentation. The potential of the computer for detailed data collection and its ability to automatically transform raw scores to meaningful test results are major advantages which relieve the tester of tedious scoring procedures. Finally, the computer allows for measurement of a large number of variables related to the child's performance which would be impossible for an individual tester to record, for example, response latencies.

The Computerized Auditory Skills Battery

The Auditory Skills Battery (ASB) was developed in an attempt to make use of the advantages of automated assessment procedures in auditory skills testing. The unique capabilities of the LEK 421 Portable Learning Assessment Terminal (PLAT) for audio and visual presentation of information and for processing touch responses make it particularly useful for testing children (Fig. 1).

Figure 1. Child interacting with touch sensitive screen during the testing session

Under computer control, audio messages are presented to the child via a random access tape recorder and pictures are presented via a random access slide projector. The screen of the slide projector is touch sensitive, enabling the computer to record the child's touch in response to an audio message. The tester is able to interact with the computer via the keyboard of the printer, which is another module of the terminal (Fig. 2). However, the tester is only minimally involved. Once the child is registered and the testing is begun, the computer administers the appropriate audio and visual messages and automatically records the child's responses.

The computer-administered Auditory Skills Battery, or the ASB, is an adaptation of nine tests of the Goldman-Fristoe-Woodcock Auditory Skills Test Battery (23) which is administered in the standard fashion with workbook, cassette tapes and scoring sheets. The tests selected for computer administration were those relevant to language and learning disabled children. The subtests chosen from the Goldman-Fristoe-Woodcock were those adaptable to computer administration in the standard fashion. The subtests include Diagnostic Auditory Discrimination Part I, II and III, Auditory Recognition Memory, Auditory Memory for Content, Auditory

Figure 2. Accessing the Auditory Skills Test Battery

Memory for Sequence, Sound Recognition, Sound-Symbol Association and Selective Attention.

Most of these tests consist of a large number of items (300 for auditory discrimination alone) and require approximately 3 h to administer in total. For standard administration, instructions to the tester are detailed and complicated. Following the test administration, complex scoring methods are necessary to determine meaningful test results. As a result of these factors, the tests are often not sufficiently utilized by speech pathologists. The automated version which has been developed enables the administration of these tests by a technician or volunteer. These test results can then be made available prior to the speech pathologist's session with the child.

Detailed analyses of the child's errors, a profile of his performance on the battery and a summary interpretation of test results are also available from the computer. This analysis of test results is useful for treatment recommendations, and would require many extra hours of the speech pathologist's time to prepare by hand.

CHAPTER II

ASSESSMENT OF AUDITORY SKILLS

Language is the specialized human function that allows one to interact in a sophisticated way with other human beings. Language includes expressive functions, how we express ourselves orally via speech or in the written mode, and receptive functions, or how we perceive and interpret what others express to us. A wide range of auditory skills are necessary for adequate receptive language development.

Estimates of the prevalence of language disorders range from 4 to 10% of the population (24). By conservative estimate, the National Advisory Neurological Diseases and Stroke Council reported that there were approximately 12,000,000 speech handicapped persons in the United States (25). A comparable estimate based on the Canadian population would indicate approximately 1,200,000 persons. Myklebust (26) estimated that 5% of school-age children have language problems severe enough to interfere with their educational achievement. Children with language disorders begin school with a serious disadvantage. Language delays or disorders, because of their basic relationship to learning, present an educational problem of considerable magnitude. The prevalence of learning disabled children and adolescents who exhibit a language disorder syndrome varies from 39% to 63% (27-29). These disorders may be characterized by difficulties with comprehension or expression at the sound, word and/or sentence level, deficits in immediate recall of words, sentences and/or digits, and word finding and conceptual problems. Only with identification and provision of remedial programs early in life can a child be assured of actualizing his potential.

The automated Auditory Skills Battery was developed to provide an efficient and effective screening and diagnostic device for the assessment of the auditory component of a child's receptive language development. Various assessment procedures have been utilized for testing auditory skills (30). One of the most complete assessment procedures is the Goldman-Fristoe-Woodcock Auditory Skills Test Battery (23). According to the published manual for the G-F-W Battery, its intent is to identify persons who are deficient in auditory skills and to describe these deficiencies.

Various tests have been developed over the past decade to evaluate the emerging language skills of children and to measure linguistic abilities. More recent tests have been designed to measure specific linguistic characteristics such as auditory perceptual abilities; linguistic processing at the levels of phonology, morphology and syntax; semantic processing at the word and concept level and the figurative aspect of language and thought; auditory memory deficits for spoken language; word retrieval and recall abilities; input organizational abilities for words and concepts; abstraction, symbolization and conceptualization abilities.

The Goldman-Fristoe-Woodcock Battery

The Goldman-Fristoe-Woodcock Auditory Skills Test Battery (23) is one such measurement instrument which can be employed with subjects from ages 3 to 80. The battery consists of separate subtests each with its own administration and interpretation procedures. This particular test was chosen for automation because many of the tests evaluate linguistic levels of function in the area of receptive skills consequently requiring a non-verbal pointing response to a controlled stimuli presented sequentially. The specific auditory perception skills subtests of the G-F-W Battery which were automated include:

1. Selection Attention

Auditory-figure ground perception is the ability to focus on selected parts of the profusion of auditory stimuli usually around an individual. This ability is critical in a classroom learning situation which frequently has considerable background noise. Several studies (31, 32) have indicated that there is a close relationship between auditory-figure ground perception and the development of speech and language skills. Other studies (33-35) have indicated that auditory perceptual problems may influence such skills as auditory-figure ground abilities, phoneme discrimination and phoneme sequencing.

2. Auditory Discrimination

The ability to distinguish between sounds which are very similar is referred to as auditory discrimination. Functional speech production difficulties or misarticulations have been related to difficulties in auditory discrimination (36-41). In addition, some studies have suggested that poor speech sound discrimination may contribute to poor reading skills.

3. Recognition Memory

Recognition memory refers to the ability to recognize whether or not an element such as a word has been heard in the immediate past. Words for this skill were chosen for familiarity, concreteness, common length (five to eight letters in length), and syllabification (two-syllable words). Deficits in auditory memory contribute to verbal learning difficulties and communication disorders.

4. Memory for Content

Memory for content is the ability to recognize a set of elements that occurred in a recent auditory event without regard for the sequence of those elements. This skill does not require a recall of the items but only a recognition response.

5. Memory for Sequence

Memory for sequence refers to the ability to remember the order of a set of elements in a recent auditory event. In order to efficiently use language, an individual must be able to remember language events which occurred and in which order. In general, memory performance concerning the sequence of events has been related to articulation, language and reading skills (33, 42-44). Deficits of auditory memory for spoken language, recall and retrieval are also problems frequently associated with children with language based learning disabilities (45-50).

6. Sound Recognition

Sound recognition refers to the ability to recognize speech sounds. A sequence of isolated phonemic components of a word are presented and a subject is required to select from a set of four pictures the image that the sounds would name if integrated into a word. Strategies of sound blending and/or elimination of inappropriate pictures can be used by an individual to solve the problems of this task. Individuals with deficits in input organization for words and/or deficits in linguistic processing, integration, and conceptual synthesis will exhibit language learning disabilities (49, 51-55). They may also have reading difficulties (56) and the disability may interfere with normal articulation development (57, 58).

7. Sound Symbol Association

Sound symbol association refers to the ability to learn new associations between unfamiliar auditory and visual stimuli. An oral presentation of a nonsense syllable and a novel abstract visual figure are paired. A subject must then select the correct figure from a table with several abstract visual figures. Ths task requires paired-associate learning which is required in academic tasks such as learning the spelling of nonphonetic words, sight reading, learning sounds associated with letters or names of the numbers of the alphabet.

Limitations in sound symbol assocation abilities have significant effects on learning and reading, both of which require symbolization, abstractions and conceptualizations (26, 59-61).

Test Criteria Required for Adaptation

The Goldman-Fristoe-Woodcock Auditory Skills Test Battery was chosen for computer adaptation on the basis of the following criteria:

- the tests measured auditory perceptual skills for individuals who function normally and/or who experience learning and/or communication difficulties and cover a wide age range of subjects

- the tests were receptive in nature, requiring nonverbal touch responses which could be documented by a human tester and by a computer

- the tests could assess a broad range of skills including auditory attention, discrimination, sound analysis, sound symbol relationships and auditory memory

- training procedures were available to ensure that the subject understood the task and knew what concept or word the pictures presented were designed to represent

- the test procedures were adaptable to computerized presentation and included a standardized presentation form

- pre-recorded tapes for auditory stimuli presentation were able to be used in both the standard and automated format to limit changes in the test presentation

- examiner instructions were concise and easy to follow, and procedures for test administration easy to learn

The Goldman-Fristoe-Woodcock Auditory Test Skills Battery was designed with may of these criteria in mind. In 1977, the first author received permission from American Guidance Service, Inc., to adapt this test for computer-assisted presentation.

CHAPTER III

THE LEKTROMEDIA 421 PORTABLE LEARNING ASSESSMENT TERMINAL (PLAT): HARDWARE

As part of a research program in Computer-Aided Learning (CAL), the National Research Council of Canada has worked closely with the Lektromedia Division of Goodwood Data Systems Ltd. in their development of a family of microprocessor-based multi-media computer terminals. These include the Audio Visual Computer Aided Tutor (AVCAT) used by Air Canada for aircrew training, the LEK-920 series Systems and Procedures Trainer (SPT) recently acquired by United Airlines, and the LEK-300 series of multi-media terminals being used by the Canadian Forces in the development of CAL materials for maintenance technician training.

The terminal that was developed for the administration of the ASB program is a member of the family of Lektromedia terminals. It was designed to be portable and has been designated as the LEK-421 Portable Learning Assessment Terminal (PLAT).

The LEK 421 terminal offers audio and visual capabilities, a touch sensitive screen, a teletype printer for hardcopy printing and an acoustic coupler for easy telephone dial-up to the supporting computer system. The terminal consists of three main components: the printer/-acoustic coupler, the audio/controller, and the slide/projector/touch panel screen as illustrated together as a functioning unit in Fig. 3. A description of these components and instructions for use are outlined in this chapter.

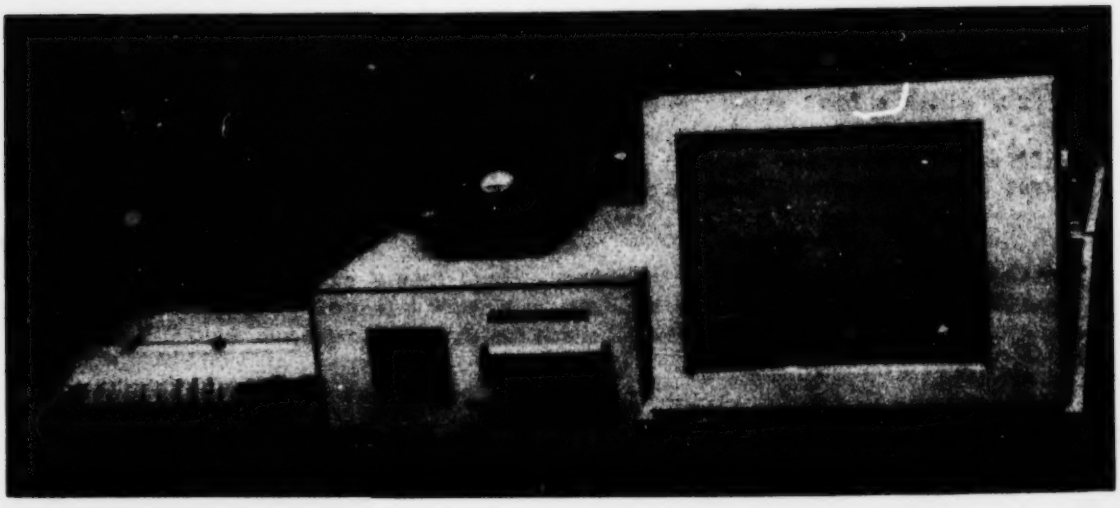

Figure 3. PLAT 421 Terminal

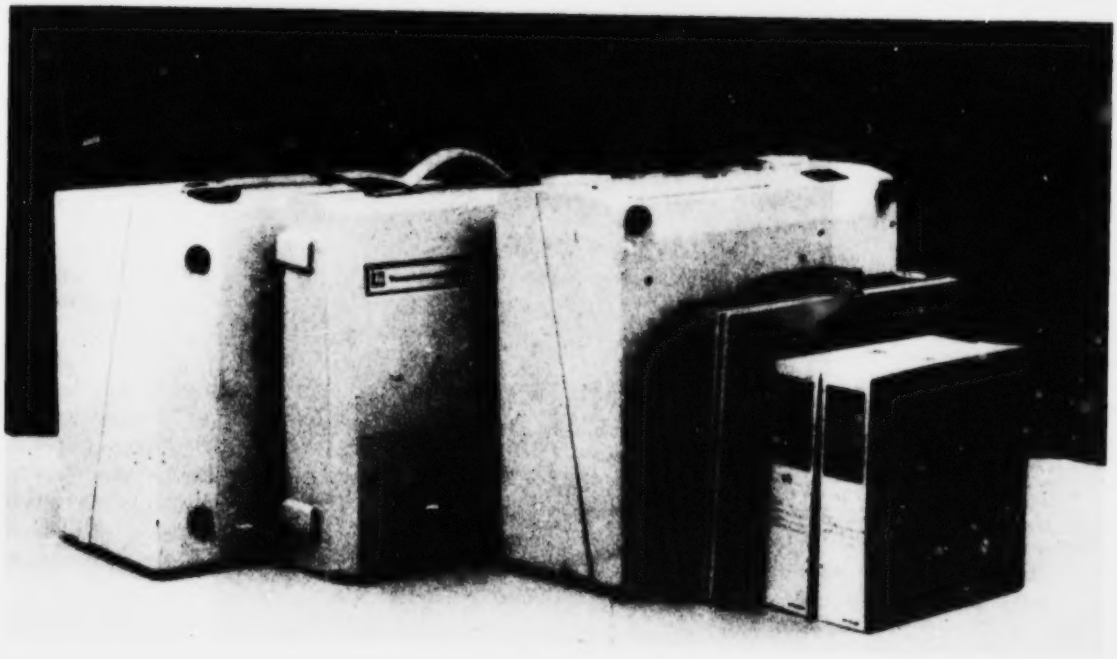

Figure 4. Components of terminal

Figure 4 illustrates the components of the terminal, including cassette tapes and slides, packed for transit.

Printer/Acoustic Coupler

The printer component of the terminal is a Texas Instruments Silent 700 Model 745 Portable Terminal with built-in acoustic coupler. This printer uses a thermographic printing method on heat sensitive paper to produce clear, upper case letters. This terminal is lightweight (5 kg). It comes with a keyboard cover with carrying handle and is easily transportable. The built-in acoustic coupler consists of flexible rubber cups into which the hand set of the telephone is plugged. The unit packed for transit is pictured in Fig. 5 and ready for operation in Fig. 6.

The printer ON-OFF switch is located in the upper right corner of the unit and must always be in the ON position when the terminal is in use. There are three switches on the lower right side of the keyboard. That marked LOW SPEED should be switched to the right for high speed; that marked HALF DUP should be switched to the left for on-line computer connection. The switch on the lower left side of the keyboard marked NUM should be switched to the right to indicate that the extra number pad available on the letter keys is not operational.

Figure 5. Printer packed for transit

Figure 6. The printer: ready for operation

Figure 7. Split-apart protective case for audio controller ready for transit

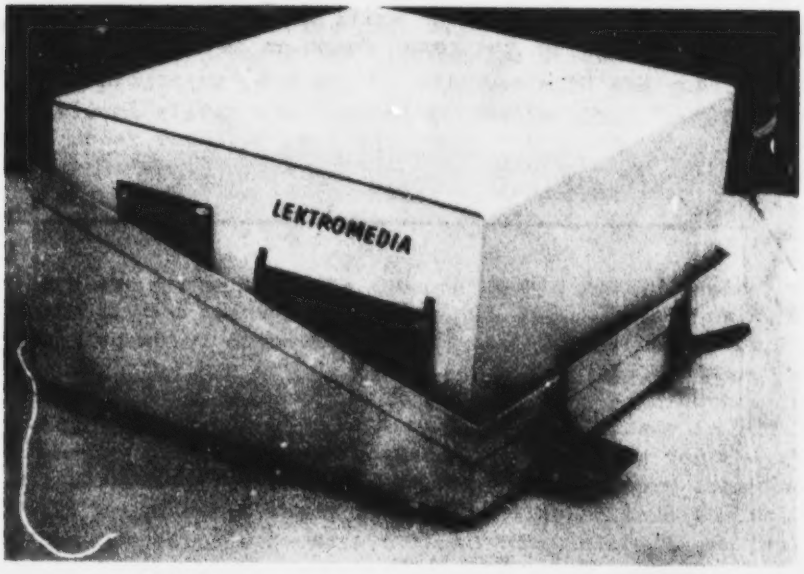

Figure 8. Packing of audio controller in case

Audio/Controller

This unit contains all the control electronics plus the audio cassette component. It is transportable in a split-apart protective case with a carrying handle (Figs. 7 and 8). The unit weighs approximately 16 kg. The audio component of the terminal is a random access tape player. Tapes are inserted into the player on the front of the unit as is shown in Fig. 9.

Various switches and indicator lights are also visible in Fig. 9. The ON/OFF button on the front of the unit should be turned to the on position whenever the terminal is in use. This button also serves to adjust the volume level of the audio cassette component. The small red indicator light marked POWER signals that the unit is on. The second red unmarked indicator light beside the cassette component signals that the touch panel is enabled and ready to register a touch on the screen. The port marked HEADSET allows for connection of earphones to the audio component. The INTL SPEAKER switch when in the off position allows audio messages to be heard only through the earphones; in the on position, audio is available via earphones as well as via the speaker visible on the front of the audio/controller unit.

The audio/controller has a number of controlling switches on the back face of the unit (Fig. 10). The switch marked ON-LINE/LOCAL should be in the ON-LINE position for regular operation of the terminal. That marked FULL-HALF should be in the FULL position to indicate full duplex. The ODD/MARK/EVEN switch should be in the even position. The two remaining switches should be adjusted so that their combined position indicates the 300 position for 300 baud. The small red unmarked button functions to reset the terminal. Use of the reset function is outlined in Appendix II.

Figure 9. The audio controller

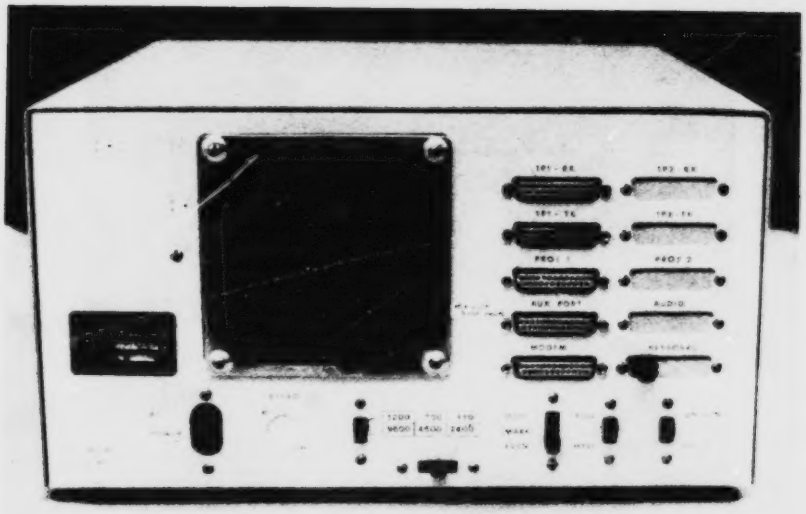

Figure 10. Controlling switches on the back of the audio controller

Slide Projector/Touch Panel Screen

This unit contains a random-access 35 mm projector, a Kodak Ektagraphic RA-960 (Fig. 11), which forms a rear-projected image on a screen overlaid with a touch sensitive panel (Fig. 12). The unit folds together to form its own carrying case with handle and weighs approximately 14 kg (Fig. 13). One slide tray can be stored for transit within this unit. The projector lens may be adjusted with the control knob; however, individual slides are focused automatically. The projector functions totally under computer control. Only the slide trays are changed manually. There are no switches to adjust on this unit.

Connectors

There are three separate and one double set of cables connecting the three units of the terminal. The set of double connector cables is joined to one plug which connects at the back face of the printer as is shown in Fig. 14. The two cables are labelled AUX and MODEM and connect to the AUX and MODEM ports on the back face of the audio/controller unit, shown unconnected in Fig. 15 and with the connection made in Fig. 16. Above these ports are three additional connecting ports for the three single cables as is visible in Figs. 15 and 16. The port labelled PROJ 1 connects to the round cable which in turn is plugged into the socket on the back of the projector case with a round screw plug (Fig. 17). Care should be taken to adjust the orientation of the round screw plug in the socket. The ports labelled RX and TX on the controller (Fig. 15) connect

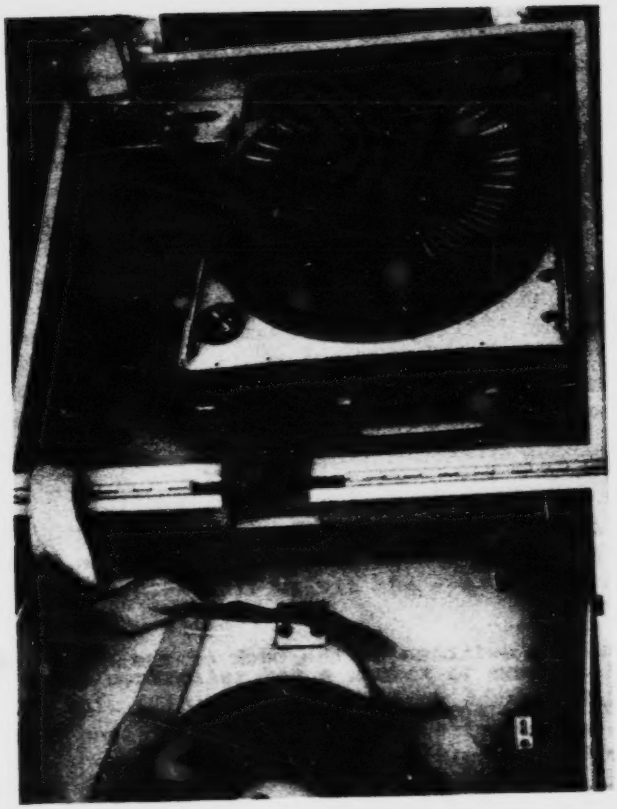

Figure 11. Random access 35 mm projector in portable case

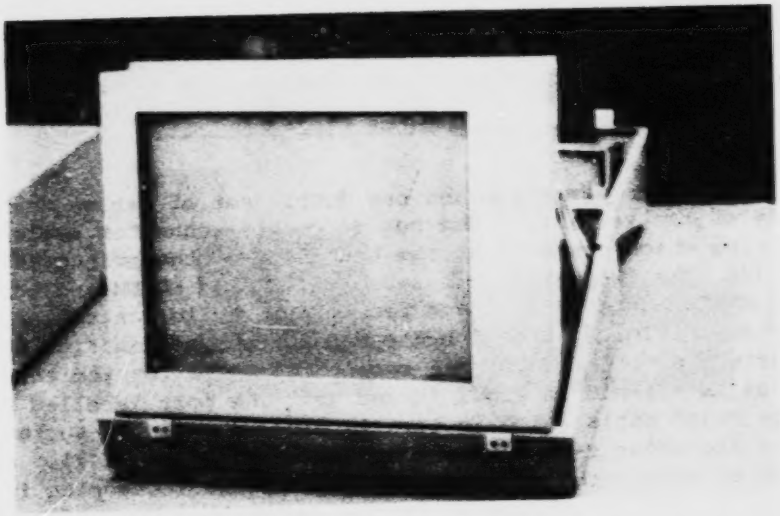

Figure 12. Touch sensitive panel in projector unit

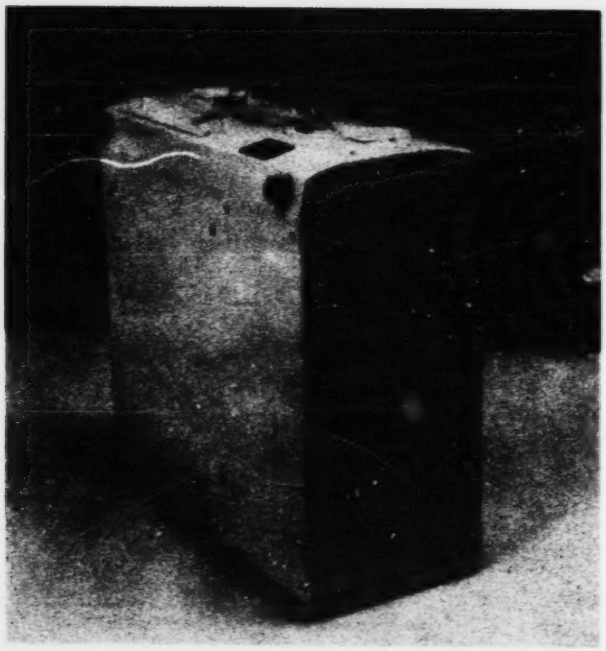

Figure 13. Projector/screen unit in a carrying case

Figure 14. Double connector cables attached to printer

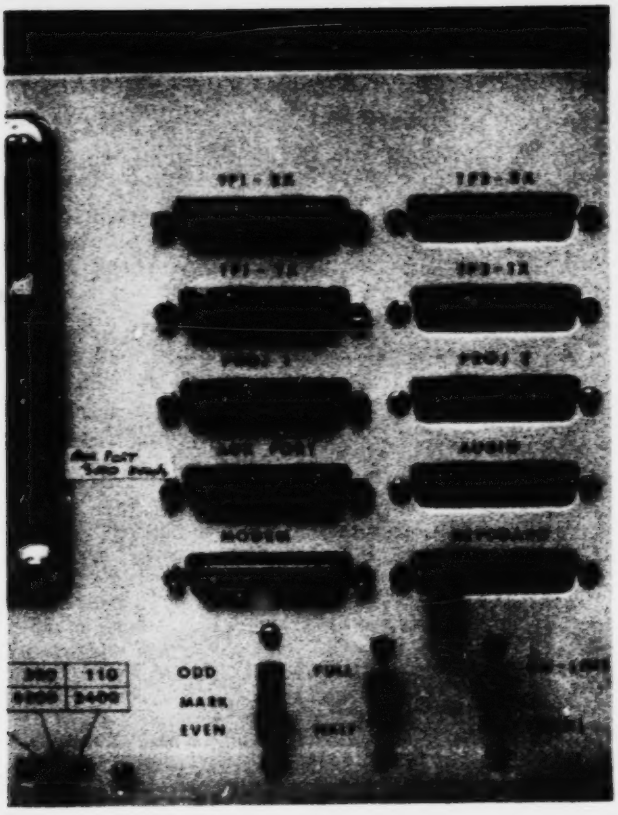

Figure 15. Back of audio/controller before connections

to the corresponding ports beside the slide projector with the flat connecting cables as in Fig. 18. Care should be taken to connect the two RX ports with the RX cable and the two TX ports with the TX cable. All connections on the back face of the controller are illustrated in Fig. 16.

It should be noted that all connections must be made before any of the power cords are plugged into the electrical outlets. All connecting cables may be screwed into their corresponding ports to ensure the connections. All cables should be disconnected from ports and folded for transit.

There are three AC power cords, one from each of the units of the terminal, requiring three electrical outlets for operation. The power cords on the printer and on the audio/controller may be removed from the back faces of these units for packing and transit. The cord for the projector/touch panel unit is not removable and is simply folded beside the projector for transit.

Figure 16. Connections to back of audio/controller

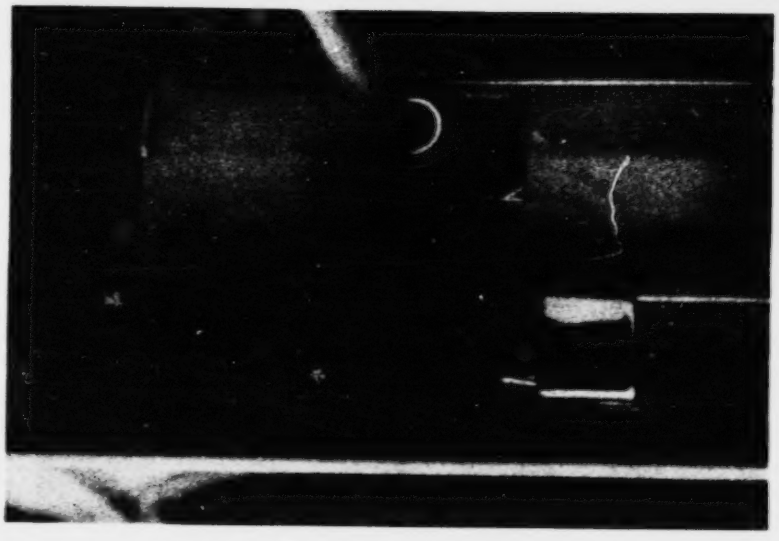

Figure 17. Screw plug at back of projector case

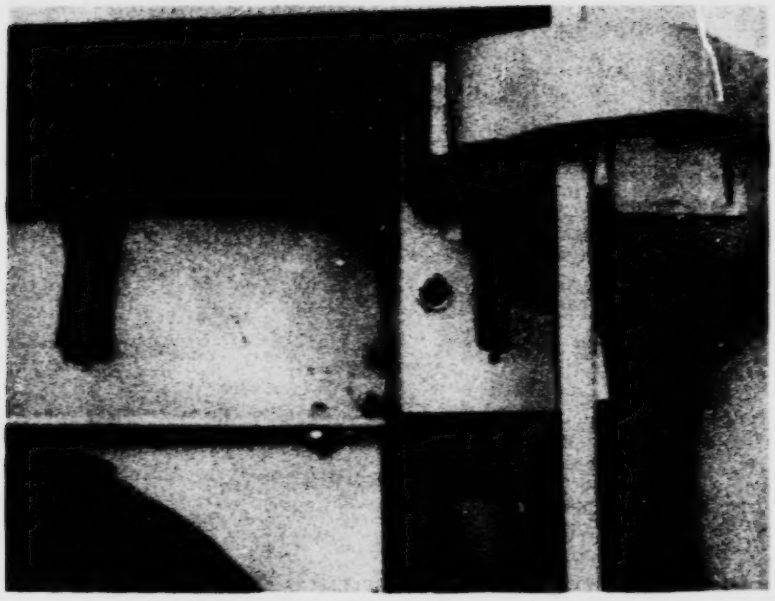

Figure 18. Corresponding RX and TX connections on projector unit

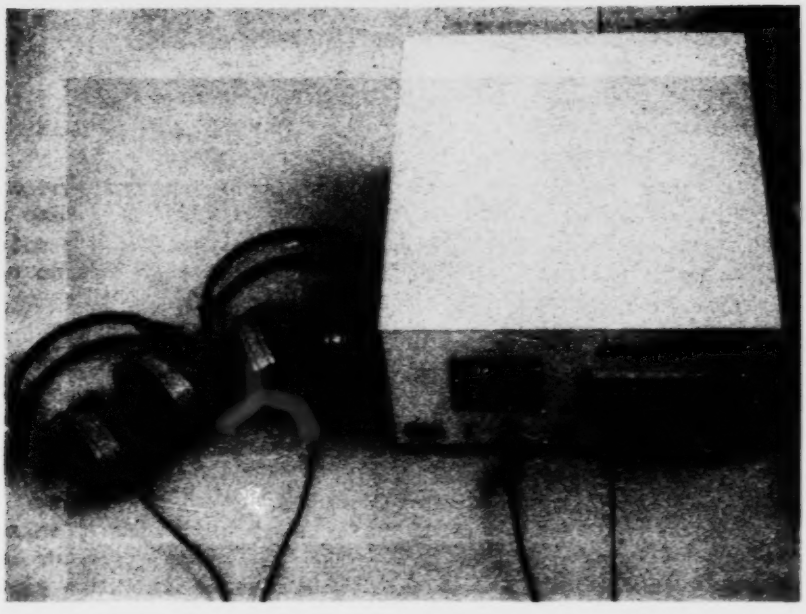

Figure 19. Earphone jack on front face of audio/controller

Earphones

Earphones are an accessory to the LEK 421 terminal and are useful for blocking out ambient noise and the white noise caused by the fans in the three units of the terminal. The sets of earphones are connected in parallel so that both the child and the examiner are able to hear the same message. The earphone jack is on the front face of the audio/controller (Fig. 19).

CHAPTER IV

THE NATAL LANGUAGE: SOFTWARE

An Overview

NATAL is a high-level computer programming language designed to respond to the needs of the course author for the preparation of teaching and testing materials for delivery by computer. The name is an acronym derived from NATional Author Language, an expression that reflects both the objectives and the process of its development. The basis for NATAL is to be found in a functional specification for a CAL language prepared by a Working Panel of the NRC's Associate Committee on Instructional Technology. The panel was made up of prominent computer scientists and educators from centres throughout Canada where they were actively engaged in a variety of CAL projects. In addition, recommendations were solicited from and discussions were held with experts at CAL centres in other countries. The result of the panel's work was a statement of the requirements of a CAL language that responded to a broad range of application requirements and could form the basis of an advanced Computer-Assisted Learning System, which would address the problems of content productivity, portability and delivery of computer-based teaching and testing materials. While other languages have been developed for CAL applications, none have the power and flexibility of NATAL.

A high priority during the NATAL development was assigned to the requirements for portability and productivity. NATAL is designed to be used on many different computer systems so that courseware can be readily exchanged and disseminated. This is not the case today for most specialized programming languages. The user often finds that software cannot be shared, even between the members of the same series of computer hardware, without modifications to his programs. A further aspect of portability addressed by the NATAL implementation is the incorporation of facilities to support the execution of user programs on a variety of terminal equipment. Thus, the NATAL program can be used on functionally equivalent terminals without the user having to be concerned with details of minor differences in terminal control.

Within the framework of productivity improvement, the NATAL language is designed to be used by persons whose skills are in education, not necessarily in Computer Science. NATAL has a sophisticated file system so that student records can be kept, retrieved, updated and reproduced. Powerful computational and logical functions are available for a wide variety of instruction, drill and testing. Through the file system and computational facilities, NATAL permits a separation of instructional strategy and content and thus readily supports those applications for which the content must be continuously updated. This approach permits such updating to be carried out without any requirement for programming skills.

Of particular importance in CAL applications is the need for the terminal to support close communication between the student and the subject matter, which often requires the use of special devices. NATAL responds to this requirement in that it can readily control a large variety of external devices such as random access tape and cassette players, video disc players, clocks, etc. It permits a high degree of flexibility in the choice of terminals.

NATAL-II is currently available on the DECsystem-10 and the Honeywell Level-6 minicomputer and will soon be available on IBM mainframes. It is expected that ths list of implementations will expand with increasing use of the language.

Using the NATAL System

To prepare a course program for testing or training, a course Author constructs a NATAL file using the TEXT EDITOR of his computer. The file consists of PROCEDURES, FUNCTIONS, and UNITS. These "source files", once free of all errors, are translated into an intermediate language code (ILC). A "directory" of ILC elements is formed and these are combined into executable "course files".

When the course is actually run, a user interacts with an executive program that allows for multiple simultaneous users of this system. The course is "interpreted" by a machine language program which is available on the particular computer being used during this run. It is important, however, to emphasize that a typical user of the ASB system or other programs using NATAL needs to know nothing about NATAL itself nor about the details of the foregoing course preparation process.

The NATAL Language

A course program written in NATAL consists of a collection of PROCEDURES, FUNCTIONS, UNITS and may use one or more data FILES. The UNIT is a key element in the NATAL language in that it contains most of the special features related to the educational orientation. The UNIT may be considered as a module that executes one instructional transaction which may be very simple or very complex. The operations contained in a UNIT are those that would be expected in any instructional transaction whether carried out through an interaction with the computer, the classroom teacher or the individual test administrator. Within the UNIT is provision for DISPLAY of information (written, pictorial or spoken); the acceptance of a RESPONSE (typed or graphic by means of pointing); EDITING of the response to remove extraneous information; CATEGORIZATION or classification of the response through comparison with one or more targets; and presentation of additional information to REINFORCE the response or to support a RETRY in the form of a new response.

An individual UNIT may contain no more than a single display operation or it may contain a complex editing and categorizing hierarchy.

The following is an example of a simple UNIT whose only purpose is to display (or play) one audio message:

```
*GFW_PUT_AUDIO: UNIT(AUDIO_MESSAGE);
                DISPLAY & D(AUDIO, ONC, AUDIO_MESSAGE) &;
 END;
```

This code is called periodically during a test to play the tape segment whose numeric value is given by the variable AUDIO_MESSAGE. The DISPLAY statement indicates that a presentation of material is anticipated; the symbol "&D" indicates that a particular device is about to be activated; AUDIO indicates that it is the random access cassette tape recorder which is being activated; ONC turns on the device and continues immediately to the processing of the program so that, for example, the student's response could be accepted even while the tape is still running; and the use of the variable AUDIO_MESSAGE allows this particular bit of code to be reused for every instance where the cassette tape recorder alone is to be used. The name of this unit is GFW_PUT_AUDIO.

There are hundreds of such units in the completed ASB program. Some of these units have dozens of lines of code. Each unit had to be carefully tested before the program was completed.

The controlling elements of a software system are called PROCEDURES. These are the means by which the sequence in which units are called is determined; the logical sequence of the course proceeds; the data are read from or written to files; and other procedures can be called to act as needed. Procedures represent the managerial aspect of the program. A typical (but unlikely) procedure called PLAY, which would play the first five segments of a cassette tape might be:

```
PLAY:                    PROCEDURE
                         DO X = 1 to 5;
                                 CALL *GFW_PUT_AUDIO (X):
                         END;
END;
```

The "DO" up to the first "END" constitutes a loop which repeats the call of the previous unit exactly five times. The second "END" terminates the procedure.

The software provided in the ASB course contains many procedures. Procedures can be quite long and complex. The user of a course need not understand precisely how these procedures "work", or exactly what they do. Similar situations are encountered daily when one uses a telephone for a long distance call, makes an airplane reservation, or drives certain new automobiles. In each instance there is software controlling an aspect of one's activities without one being required to understand the precise nature of this software or its actual implementation. One calls such implementations "friendly" because the user is not called upon to

exhibit particular knowledge of the software.

The FUNCTION plays a supportive role. It is called by the unit or the procedure for graphic, edit, or categorization purposes. For example, an EDIT function could fill in empty blanks in a student's response when unneeded spaces between letters or words were inserted, so as to prevent an essentially correct answer from being misinterpreted by the computer as being wrong. The graphics functions permit sophisticated displays on a computer terminal screen.

Documentation

It is important to specify the requirements of a program in complete detail before a programmer can proceed with the program development. A sample of the actual documentation which was provided for the Auditory Skills Battery Test is illustrated in Table 1 and additional information is available in an appendix of this document. From this type of information, the programmer can build the units and procedures of a software package, in this case the ASB.

The information given here is not sufficient to do the programming. It is also necessary to specify the number of each slide in the slide tray, the number of each audio message on the tape, and the screen co-ordinates of acceptable and non-acceptable touches for each slide. Given all this information, the programmer can then begin to create the necessary source file for the software.

Size

It is difficult to compare NATAL program sizes to other languages because the program is stored in a compact intermediate language code which is translated into machine language at run time by an "interpreter" software package. The COURSE file for the ASB requires 663 BLOCKS of 128 5-byte words. This is equivalent to 424 K. The COURSE file is normally read and interpreted one page at a time and hence the space requirement on the MAIN FRAME is not excessive for a large system such as an IBM 370. The interpreter can presently reside in PASCAL on a 64 K microcomputer and the computerized ASB is currently running on a QuPro Q-Engine microprocessor at the Children's Hospital of Eastern Ontario.

CHAPTER V

THE AUDITORY SKILLS BATTERY: COURSEWARE

The Auditory Skills Battery (ASB) adaptation of the Goldman-Fristoe-Woodcock (G-F-W) Auditory Skills Test Battery was designed for computer-assisted administration of auditory tests to a child, with the help of an examiner, via a LEK 421 PLAT terminal. The program was written in a user-friendly format so that the examiner is able to administer tests to the child with relative ease. The user interacts with the computer by typing via the printer keyboard. Messages are sent to the user also via the printer. Once the user has accessed the program, by logging onto the computer, the program asks questions and gives directions to the user. Help is available at various stages throughout the program.

Log on procedures are computer dependent and therefore will not be outlined in this discussion. The directions which follow refer to procedures within the ASB computer program itself.

Once the ASB program is accessed there are nine modes of operation available to the user. These program modes are illustrated in Fig. 20.

The option to choose a particular program mode is presented to the user as in Fig. 21. The new user would be wise to choose HELP mode in order to familiarize himself with the capabilities of the program and the method of interacting with the terminal as outlined in Figs. 21 and 22. In HELP mode the definition of the program is given and the various modes of the program are identified and explained.

The user is informed that the computer will prepare a file for each child tested which includes background information collected in REGISTRATION mode and test results collected in TESTING mode. A child's file is accessed with his computer ID code, made up of his initials and birthdate, which is established in REGISTRATION mode. Test results may be output in PROFILE mode, which outputs a six page report and interpretation of test results, or in ANALYTIC mode, which allows for test scores to be retrieved for groups of children at a time. ENQUIRY mode enables the user to output a child's ID code and a list of tests that have been administered from typing his name. ENQUIRY modes is also able to access the tests administered to particular groups of children. If a testing situation is interrupted for any reason, test administration may be resumed via CONTINUE mode. Any background registration that may need to be revised or corrected, or subject files that should be deleted, may be changed in MAINTENANCE mode. Finally EXIT mode is the means by which the user may terminate use of the ASB program. The use of each program mode is outlined below.

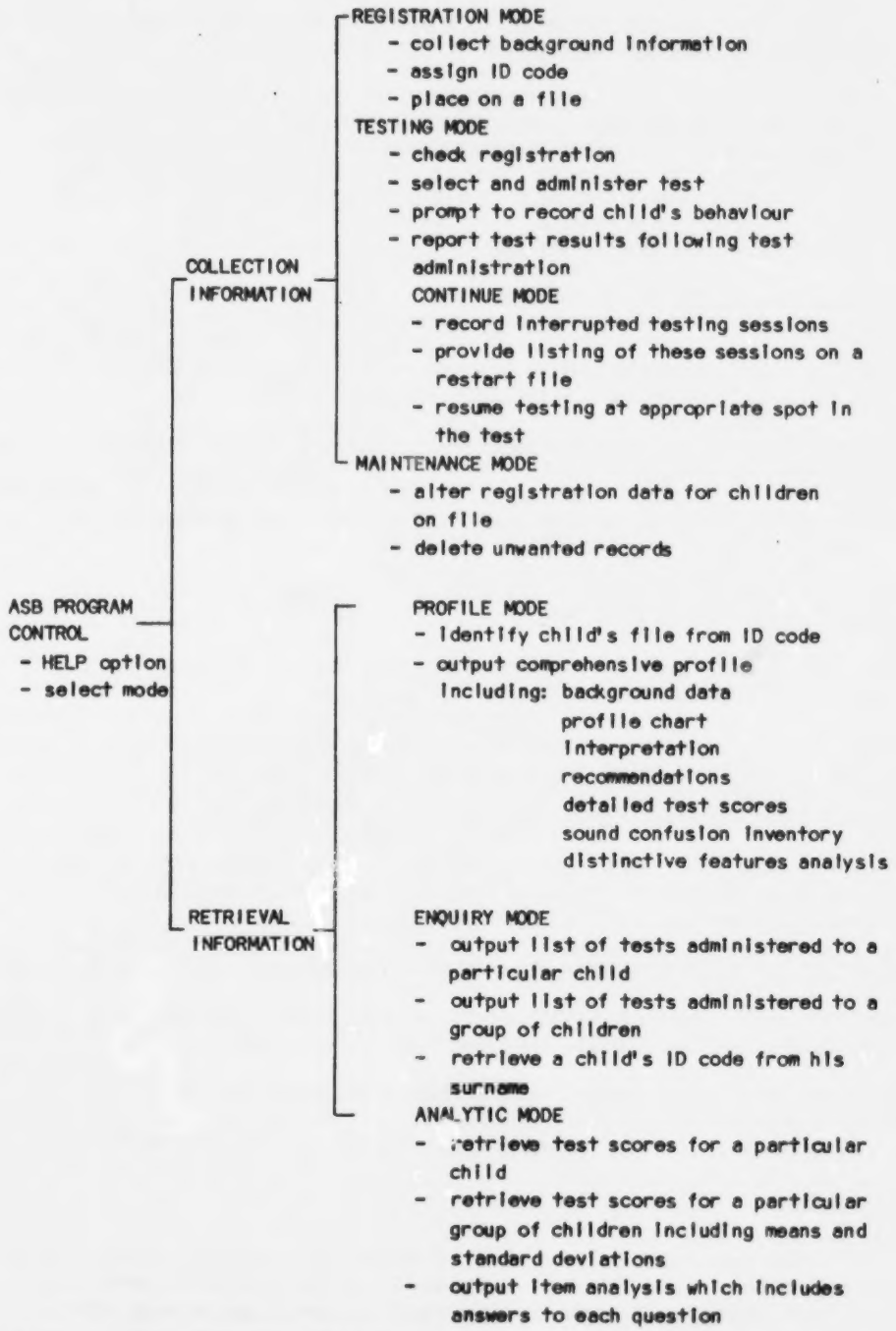
ASB PROGRAM CONTROL
- HELP option
- select mode
COLLECTION INFORMATION
REGISTRATION MODE
- collect background information
- assign ID code
- place on a file
TESTING MODE
- check registration
- select and administer test
- prompt to record child's behaviour
- report test results following test administration
CONTINUE MODE
- record interrupted testing sessions
- provide listing of these sessions on a restart file
- resume testing at appropriate spot in the test
MAINTENANCE MODE
- alter registration data for children on file
- delete unwanted records
RETRIEVAL INFORMATION
PROFILE MODE
- identify child's file from ID code
- output comprehensive profile
including: background data
profile chart
interpretation
recommendations
detailed test scores
sound confusion inventory
distinctive features analysis
ENQUIRY MODE
- output list of tests administered to a particular child
- output list of tests administered to a group of children
- retrieve a child's ID code from his surname
ANALYTIC MODE
- retrieve test scores for a particular child
- retrieve test scores for a particular group of children including means and standard deviations
- output item analysis which includes answers to each question

Figure 20. Auditory Skills Battery program design

```
          TYPE        T,P,M,E,A,X,R,C
   OR     TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?H

   ASB IS THE COMPUTER PROGRAM, OR COURSE, DESIGNED TO
ADMINISTER AND ANALYZE A COMPUTER ADAPTED VERSION OF THE
GOLDMAN-FRISTOE-WOODCOCK AUDITORY SKILLS TEST BATTERY. THIS
IS A BATTERY OF RECEPTIVE LANGUAGE TESTS FOR ASSESMENT OF
THE AUDITORY SKILLS OF DISCRIMINATION, MEMORY, SELECTIVE
ATTENTION, AND SOUND-SYMBOL ASSOCIATION.

   THE VARIOUS MODES OF THIS PROGRAM ARE LISTED BELOW.


   T REFERS TO TESTING MODE WHICH ALLOWS  ADMINISTRATION OF ANY TEST
        IN THE AUTOMATED GFW AUDITORY SKILLS BATTERY.

   R REFERS TO REGISTRATION MODE WHICH IS USED TO COLLECT BACKGROUND
        INFORMATION ABOUT A CHILD AND TO REGISTER HIS ID CODE IN A
        FILE WHICH STORES TEST RESULTS. EACH CHILD SHOULD BE REGISTERED
        ONLY ONCE, BEFORE THE FIRST TEST IS ADMINISTERED, AND HIS
        COMPUTER ID CODE SHOULD BE RECORDED ELSEWHERE.

   P REFERS TO PROFILE MODE WHICH PROVIDES A FORMAL SUMMARY
        AND REPORT OF THE TEST RESULTS FOR ANY CHILD TESTED.

   M REFERS TO MAINTENANCE MODE WHICH ALLOWS YOU TO CHANGE OR DELETE
        REGISTRATION INFORMATION.

   E REFERS TO ENQUIRY MODE WHICH ALLOWS YOU TO QUICKLY DETERMINE
        THE TESTS THAT HAVE BEEN ADMINISTERED TO A CHILD, TO FIND
        THE CHILD'S ID BY TYPING HIS NAME, OR TO LIST GROUPS OF
        CHILDREN, ACCORDING TO REGISTRATION INFORMATION.

   A REFERS TO ANALYTIC MODE WHICH PROVIDES INDIVIDUAL ITEM SCORES
        AND DETAILED TEST RESULTS FOR PARTICULAR SELECTED GROUPS OF
        CHILDREN ON ANY PARTICULAR TEST.

   X REFERS TO EXIT MODE WHICH ALLOWS YOU TO GET OUT OF THE ASB PROGRAM.

   C REFERS TO THE CONTINUE MODE WHICH ALLOWS CONTINUATION OF A TESTING
        SESSION THAT HAS BEEN INTERRUPTED.

   H REFERS TO HELP MODE WHICH TYPES THIS EXPLANATION.
```

Figure 21. Sample printout of choice of program mode

Registration Mode

The ASB program is designed to store information about a child on a computer file. This file is initiated in REGISTRATION mode where demographic and background information such as age, grade and school is collected and the child's ID code is established. The ID code is used by the computer for any subsequent identification of the file. This code is

```
NOTES:
   1:THE "RETURN" KEY MUST BE PRESSED AFTER YOU HAVE TYPED AN
         ANSWER.PRESS "RETURN" AFTER ANSWERING EACH QUESTION.

   2:TEST ADMINISTRATION MAY BE INTERRUPTED BY TOUCHING THE BOX
         MARKED IN THE LOWER LEFT CORNER OF THE SCREEN. IF THE
         PROGRAM IS STOPPED AT THIS POINT, IT MAY LATER BE RESTARTED
         USING C MODE.


   3:A MAJOR PROGRAM INTERRUPTION MAY BE OBTAINED BY PRESSING
         THE "CONTROL" KEY AND THE "C" KEY AT THE SAME TIME.
         THIS STOPS THE PROGRAM. TESTING MAY BE RESUMED BY USING C MODE.
         THIS INTERRUPTION PROCEDURE SHOULD BE USED ONLY WHEN MAJOR
         HARDWARE PROBLEMS OCCUR.


            TYPE        T,P,M,E,A,X,R,C
   OR       TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND      PRESS THE RETURN KEY.
```

Figure 22. Sample printout of notes to user

composed of the three initials from the child's name and his birthdate. For example, the ID code for Jeffrey S. Jones, born May 25, 1975 would be JSJ250575.

Information is collected in REGISTRATION mode by interactive questioning of the examiner. Questions are presented via the printer and answered by the examiner via the printer keyboard. The procedure is outlined in Fig. 23. Options following the registration questions allow the user to check that the information has been typed in correctly and to make any necessary corrections or changes.

Children should be registered with REGISTRATION mode before any tests are administered. The results of tests administered to children who are not registered will be available upon completion of the test only; the information will not be stored and no profile report will be available.

Testing Mode

Once testing mode is accessed the user is asked if the child to be tested has been registered in the program. Testing may be conducted without registration but the test results will not be saved. A warning message to this effect will appear as in Fig. 24. An ID code is necessary even for non-registered test administration as this code determines the child's age. This information is necessary for transformation of raw test scores to more meaningful percentiles and standard scores.

If the child has been registered, the program will progress as in Fig. 25. The user is asked to enter the child's ID code and to choose which test is to be administered. If the user is unfamiliar with the

```
30
          TYPE        T,P,M,E,A,X,R,C
   OR     TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?R
DO YOU WANT TO REGISTER A CHILD? Y OR N
?Y
DO YOU WANT INSTRUCTIONS Y OR N
?Y


REGISTRATION INSTRUCTIONS
*************************

   THE ANSWERS TO THE REGISTRATION QUESTIONS ASKED
BE USED IN OTHER MODES OF THIS PROGRAM FOR OBTAINI
REPORT AND FOR ANALYZING TEST RESULTS. THEREFORE,
OF NAMES MUST BE ACCURATE AND CONSISTENT WITH THOS
OTHER REGISTRATION INFORMATION. TO INSURE THE NAM
AND BOARDS OF EDUCATION ARE CONSISTENT  LISTS OF
AVAILABLE IN THE BOOKLET ATTACHED TO THE TERMINAL, AND SHOULD
BE REFERRED TO FOR ANSWERING THESE QUESTIONS.

   ANSWERS TO EACH REGISTRATION QUESTION WILL BE RETYPED AUTOMATICALLY
TO ENABLE YOU TO CHECK THE SPELLING. THERE IS AN OPTION AVAILABLE TO
CHANGE ANY ANSWERS FOLLOWING THE LAST REGISTRATION QUESTION.

   THE CHILD IS KNOWN TO THE COMPUTER BY HIS ID CODE WHICH IS A
COMBINATION OF HIS INITIALS AND BIRTHDATE, DETERMINED IN REGISTRATION.
THIS CODE SHOULD BE USED IN SUBSEQUENT TESTING AND ANALYZING SESSIONS
WITH THE COMPUTER AND SHOULD BE RECORDED BY THE EXAMINER IN THE ATTACHED
BOOKLET.

   1:TYPE THE CHILD'S LAST NAME
?[redacted]
2:WHAT FIRST NAME DOES THE CHILD USE
?JEFFREY
JEFFREY
3:PLEASE TYPE THE FIRST LETTER OF THE CHILD'S FIRST NAME,MIDDLE NAME,
AND LAST NAME (IF NO MIDDLE NAME, USE THE NUMBER 0 )
?JSJ
JSJ
4:WHAT IS THE CHILD'S DATE OF BIRTH
    PLEASE TYPE TWO NUMBERS FOR THE DAY    FOR EXAMPLE, THE NINTH =09
                TWO NUMBERS FOR THE MONTH   FOR EXAMPLE, FEBRUARY=02
                TWO NUMBERS FOR THE YEAR  FOR EXAMPLE, 1965=65
                FEBRUARY 9TH,1965 WOULD BE TYPED 090265

?050575
050575
 5:CHILD'S SEX: BOY,  TYPE 1
                GIRL, TYPE 2

?1
1
 6:WHAT IS THE CHILD'S GRADE LEVEL
         FOR PRESCHOOL TYPE P
         FOR KINDERGARTEN TYPE K
         FOR GRADES 1 TO 13, TYPE THE APPROPRIATE NUMBER.

?1
1
```

Figure 23. Registration Mode

```
 7:WHAT SCHOOL DOES THE CHILD ATTEND
    TYPE THE SCHOOL NAME EXACTLY AS IT APPEARS IN THE ATTACHED BOOKLET.
    IF THE CHILD DOES NOT ATTEND SCHOOL, TYPE NONE.

?MAIN AVENUE
MAIN AVENUE
 8:WHAT BOARD OF EDUCATION
    TYPE THE NAME EXACTLY AS IT APPEARS IN THE ATTACHED BOOKLET.
    IF THE CHILD DOES NOT ATTEND SCHOOL, TYPE NONE.

?OTTAWA
OTTAWA
 9:WHAT IS THE CITY

?OTTAWA
OTTAWA
10:WHO IS THE PRESENT EXAMINER
         PLEASE TYPE YOUR INITIAL AND LAST NAME
         DO NOT USE A PERIOD AFTER THE INITIAL.

?J BROWN
J BROWN
11:THE CHILD WAS REFERRED BY:
    ( TYPE THE TITLE AND LAST NAME OF THE DOCTOR, TEACHER, OR
      WHOMEVER REFERRED THIS CHILD FOR ASSESSMENT,
      FOR EXAMPLE, DR SMITH, OR MRS JONES.
      DO NOT USE A PERIOD AFTER THE TITLE. )

?DR LESLIE
DR LESLIE
12:WHAT LANGUAGE DOES THE CHILD SPEAK AT HOME ( THE CHILD'S FIRST
LANGUAGE )

?ENGLISH
ENGLISH
13:DESCRIBE THE REASON THIS CHILD IS BEING TESTED
         ( PLEASE USE POINT FORM, TWO LINES MAXIMUM )

?POOR LISTENING SKILLS IN THE CLASSROOM, POSSIBLE LEARNING DISABILITIES
POOR LISTENING SKILLS IN THE CLASSROOM, POSSIBLE LEARNING DISABILITIES
14:THE CHILD'S SPEECH IS BEST DESCRIBED AS:
    ( TYPE THE RELEVANT LETTERS, FOR EXAMPLE, BCE )
         A:VIRTUALLY NONEXISTENT
         B:UNINTELLIGIBLE
         C:INTELLIGIBLE BUT WITH INCORRECT USE OF SOUNDS
         D:DISFLUENT WITH HESITATION AND ABNORMAL RATE AND RHYTHM
         E:NASAL
         F:HUSKY,HOARSE OR WHISPERY
         G:APPARENTLY APPROPRIATE FOR HIS/HER AGE

?G
G
15:THE CHILD'S GENERAL EXPRESSIVE SKILL IN THE ENGLISH LANGUAGE IS BEST
DESCRIBED AS:     ( TYPE THE RELEVANT LETTERS, FOR EXAMPLE, BCF )
         A:VIRTUALLY NONEXISTENT EXPRESSIVE LANGUAGE
         B:INCLUDING SENTENCES THAT ARE SHORT IN LENGTH FOR EXAMPLE, ME
GO OUT
         C: CONSISTENTLY OMITTED PARTS OF SPEECH
         D:IMMATURITY IN VERB FORMS
         E:IMMATURITY IN USE OF NEGATIVES
         F:LACKING IN VOCABULARY
         G:INCLUDING IRRELEVANT INFORMATION BUT WITH CORRECT SENTENCE
STRUCTURE
         H:GENERALLY IMMATURE FOR HIS/HER AGE
         I:APPARENTLY APPROPRIATE DEVELOPMENT FOR HIS/HER AGE

?GH
```

```
          TYPE        T,P,M,E,A,X,R,C
   OR     TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?T
IS CHILD REGISTERED Y OR N
?N
DO YOU WANT TO REGISTER
?N
TEST RESULTS WILL NOT BE SAVED!
ENTER CHILD'S ID
?JJJ121272
STUDENT ID = JJJ121272
```

Figure 24. Registration option

```
 T
IS CHILD REGISTERED Y OR N
?Y
ENTER THE CHILD'S ID CODE
?JSJ050575

          TYPE THE NUMBER OF THE TEST TO BE ADMINISTERED
     OR   TYPE H FOR A LISTING OF AVAILABLE TESTS
     OR   TYPE S TO STOP.

?H

 TYPE 1 for AUDITORY DISCRIMINATION PART I
      2 for AUDITORY DISCRIMINATION PART II
      3 for AUDITORY DISCRIMINATION PART III
      4 for Recognition Memory
      5 for Memory for Content
      6 for Memory for Sequence
      7 for Sound Recognition
      8 for Sound Symbol Association
      9 for SELECTIVE ATTENTION
   OR S FOR 'STOP'

?1
```

Figure 25. Test menu

program, typing H at this point will result in a listing, or menu, of the tests in the ASB along with the corresponding numbers (Fig. 25). Once a test is selected and the corresponding number entered, the title of the test appears along with an option for instructions. A familiar user could bypass the instructions and proceed directly to the test by typing N for no. The instructions include directions for the use of audio cassette tapes and slide trays as well as a description of the auditory skill to be assessed and an outline of the training and testing portions of the assessment. Figure 26 includes instructions for Test 1, Auditory Discrimination Part I.

It should be noted that following printing of the instructions there is an option to STOP or to CONTINUE with the test. This allows the

```
                AUDITORY DISCRIMINATION PART I
                ******************************

DO YOU WANT INSTRUCTIONS Y OR N
?Y
INSERT AUDIO TAPE NO. 1
INSERT SLIDE TRAY NO. 1A
HAVE READY SLIDE TRAY NO. 1B


   THIS TEST IS DESIGNED TO MEASURE THE ABILITY TO DISTINGUISH BETWEEN
SIMILAR SOUNDS BY HAVING THE CHILD POINT TO A PICTURE ON THE SCREEN THAT
REPRESENTS A WORD HE HAS HEARD FROM THE AUDIO TAPE.THIS TEST CONSISTS OF
A TRAINING AND A TESTING SECTION. DURING TRAINING THE CHILD WILL BE
GIVEN FEEDBACK FOR AN INCORRECT RESPONSE AND A NEW ITEM IS PRESENTED
ONLY AFTER A  CORRECT TOUCH IS MADE ON THE LAST ITEM. THE PURPOSE OF THE
TRAINING SECTION IS TO ASSURE THAT THE CHILD IS ABLE TO IDENTIFY ALL THE
PICTURES THAT WILL SUBSEQUENTLY APPEAR IN THE TEST.THE TRAINING SECTION
CONSISTS OF 32 ITEMS WHILE THE TEST CONSISTS OF 100 ITEMS.
   THE CHILD'S TEST RESULTS ARE AVAILABLE AT THE END OF THE TESTING
SESSION AND A SOUND CONFUSION INVENTORY OF ANY AUDITORY DISCRIMINATION
PROBLEMS IS AVAILABLE FROM THE PROFILE MODE.
   THE VOLUME OF THE TAPE PLAYER SHOULD BE ADJUSTED SO THE CHILD HEARS
THE AUDIO MESSAGES AT A COMFORTABLY LOUD LEVEL. THE TEST MAY BE
INTERRUPTED BY TOUCHING INSIDE THE BOX IN THE LOWER LEFT CORNER OF THE
SCREEN WHENEVER THE TP LIGHT IS ON.


PRESS RETURN TO CONTINUE.
PRESS 'S' TO STOP.

?S
```

Figure 26. Auditory Discriministration Test procedures

user to obtain a description of any of the tests without having to actually conduct a test administration.

During the actual test administration, test items and item scores are output on the printer to enable the user to keep track of the child's progress through the test. A score of 1 represents a correct response, a score of 2 represents an incorrect response, and 0 indicates that no response was made within the time limits of the question. Following the last test item a question referring to the validity of the test results for normative data purposes is asked. The purpose of this query is to keep invalid test results from contaminating the normative data which are being accumulated automatically on the computer files. Invalid test scores would be the result of a testing session where the child was noncompliant with the testing procedures or where tests were administered in a nonstandard testing situation, for example, for demonstration purposes. The next question allows the user to record how the child behaved during the testing session. The information may be important for subsequent interpretation of the child's test results.

Finally, the user is given the option of obtaining immediate feedback on the results of the test. The child's raw score, or total number of correct items is automatically transformed to an age equivalent score, a percentile rank, a standard score and a stanine on the basis of the normative data presented by Goldman, Fristoe and Woodcock (23).

Figure 26 illustrates how the user would proceed from choosing the TESTING mode, through administration of the test, to obtaining test results for Test 1 Auditory Discrimination Part I. Figures 27 through 32 outline procedures for the other tests of the ASB.

Continue Mode

A test administration may need to be interrupted for a variety of reasons. Problems may occasionally be encountered with the equipment or the computer, or the test administration may be interrupted by the child. The ASB program was designed to handle interruptions by storing partial test administration information in a restart file so that testing can be resumed at a later time. This file is accessed in CONTINUE mode. Figure 33 illustrates how continue mode presents the restart file, accepts an ID code and resumes testing.

Maintenance Mode

The design of the ASB program included the capability for making changes to the background information collected about a child and for

```
                AUDITORY MEMORY FOR RECOGNITION
                **********************************

DO YOU WANT INSTRUCTIONS Y OR N
?Y
INSERT AUDIO TAPE NO. 4
INSERT SLIDE TRAY NO. 4/5

   THE TEST FOR AUDITORY MEMORY FOR RECOGNITION MEASURES THE CHILD'S
ABILITY TO RECOGNIZE RECENT AUDITORY EVENTS. INDIVIDUAL WORDS WILL BE
PRESENTED ON THE AUDIO TAPE.THE CHILD WILL BE ASKED TO INDICATE IF THE
WORD WAS SAID BEFORE BY TOUCHING ONE OR THE OTHER SIDE OF THE SCREEN FOR
YES OR NO.A PRACTICE LIST OF WORDS IS PRESENTED.YOU MAY HELP HIM ON THE
PRACTICE ITEMS.IF HE RESPONDS INCORRECTLY ON MANY ITEMS,THE PRACTICE
WORDS WILL BE REPEATED. THE CHILD'S TEST RESULTS WILL BE AVAILABLE AT
THE END OF THE TEST.
   ADJUST THE AUDIO TAPE SO THE CHILD HEARS THE WORDS AT A
COMFORTABLY LOUD LEVEL. THE TEST MAY BE INTERRUPTED BY TOUCHING INSIDE
THE BOX IN THE LOWER LEFT CORNER OF THE SCREEN, WHENEVER THE TP LIGHT IS
ON.
            PRESS RETURN TO START TEST
   OR       PRESS S TO STOP
```

Figure 27. Memory for Recognition test

```
                    AUDITORY MEMORY FOR CONTENT
                    ***************************

DO YOU WANT INSTRUCTIONS Y OR N
?Y
INSERT AUDIO TAPE NO. 5
INSERT SLIDE TRAY NO. 4/5

   THE TEST FOR AUDITORY MEMORY FOR CONTENT MEASURES THE ABILITY TO
RECOGNIZE VISUALLY THE SET OF ELEMENTS THAT OCCURRED IN A RECENT
AUDITORY MESSAGE. THIS TEST CONSISTS OF A TRAINING AND A TESTING
SECTION. DURING TRAINING, THE CHILD IS ASKED TO POINT TO THE PICTURE ON
THE SCREEN THAT REPRESENTS THE WORD HE HAS HEARD FROM THE AUDIO TAPE.
FEEDBACK WILL BE GIVEN FOR INCORRECT RESPONSES AND A NEW ITEM WILL BE
PRESENTED ONLY AFTER A CORRECT RESPONSE IS MADE ON THE PREVIOUS ITEM.
THE PURPOSE OF THE TRAINING IS TO ENSURE THAT THE CHILD IS ABLE TO
IDENTIFY ALL THE PICTURES THAT WILL SUBSEQUENTLY APPEAR IN THE TEST.
TRAINING CONSISTS OF 34 ITEMS.
   THE TESTING SECTION ASSESSES THE CHILD'S ABILITY TO REMEMBER A SET OF
ITEMS. A LIST OF WORDS IS PRESENTED FROM THE AUDIO TAPE. THEN THE CHILD
SEES A SET OF PICTURES WHICH CONTAINS THOSE NAMED IN THE LIST PLUS 2
OTHERS. THE TASK IS TO POINT TO THE TWO PICTURES NOT HEARD. 16 LISTS OF
WORDS OF INCREASING LENGTH MAKE UP THE TESTING SECTION. THE CHILD'S TEST
RESULTS ARE AVAILABLE AT THE COMPLETION OF THE TEST.
   ADJUST THE VOLUME OF THE TAPE PLAYER SO THE CHILD HEARS THE AUDIO
MESSAGES AT A COMFORTABLY LOUD LEVEL. THE TEST MAY BE INTERRUPTED BY
TOUCHING INSIDE THE BOX IN THE LEFT CORNER OF THE SCREEN, WHENEVER THE
TP LIGHT IS ON.

PRESS RETURN TO CONTINUE.
PRESS 'S' TO STOP.

?S

Press RETURN to continue.
```

Figure 28. Memory for Content Test

removing data from the computer files. These functions are available in MAINTENANCE mode of the program. Figure 34 is an outline of how changes may be made to a child's file. A delete option is also available in which all data for a particular child, i.e., the child's computer file, are deleted from the records. The delete option is useful for removing files made for demonstration or program testing or training purposes, so that it is possible to retain only true test administration information in the computer file. The delete option requires the user to know the delete password, which is OPENUP. Without knowledge of the password it is impossible for a user to inadvertently delete files from the record. Once files are deleted, they may not be retrieved.

Profile Mode

PROFILE mode was intended to provide a detailed descriptive account of the results of test administration in the form of a report

```
          TYPE        T,P,M,E,A,X,R,C
   OR     TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?T
IS CHILD REGISTERED Y OR N
?Y
ENTER THE CHILD'S ID CODE
?JSJ050575

          TYPE THE NUMBER OF THE TEST TO BE ADMINISTERED
     OR   TYPE H FOR A LISTING OF AVAILABLE TESTS
     OR   TYPE S TO STOP.

?6

                    AUDITORY MEMORY FOR SEQUENCE
                    ****************************

DO YOU WANT INSTRUCTIONS Y OR N
?Y
INSERT AUDIO TAPE NO.6
INSERT SLIDE TRAY NO. 6


   THE TEST FOR AUDITORY MEMORY FOR SEQUENCE IS DESIGNED TO MEASURE THE
ABILITY TO REMEMBER THE ORDER OF RECENT AUDITORY EVENTS. THIS TEST
CONSISTS OF A TRAINING AND A TESTING SECTION. DURING TRAINING THE CHILD
IS ASKED TO POINT TO THE PICTURE ON THE SCREEN THAT REPRESENTS THE WORD
HE HAS HEARD FROM THE AUDIO TAPE. FEEDBACK WILL BE GIVEN FOR INCORRECT
RESPONSES AND A NEW ITEM WILL BE PRESENTED ONLY AFTER A CORRECT RESPONSE
IS MADE ON THE PREVIOUS ITEM. THE PURPOSE OF THE TRAINING IS TO ENSURE
THAT THE CHILD IS ABLE TO IDENTIFY ALL THE PICTURES THAT WILL
SUBSEQUENTLY APPEAR IN THE TEST. TRAINING CONSISTS OF 24 ITEMS.
   IN THE TESTING SECTION A LIST OF WORDS IS PRESENTED FROM THE AUDIO
TAPE. THEN A SET OF PICTURES REPRESENTING THESE WORDS IS PRESENTED. THE
CHILD'S TASK IS TO TOUCH THE PICTURES IN THE ORDER THAT THE WORDS WERE
PRESENTED. THE TESTING SECTION CONSISTS OF 14 LISTS OF WORDS OF
INCREASING LENGTH. THE CHILD'S TEST RESULTS ARE AVAILABLE FOLLOWING TEST
ADMINISTRATION.
   ADJUST THE VOLUME OF THE TAPE PLAYER SO THE AUDIO PLAYS AT A
COMFORTABLY LOUD LEVEL. THE TEST MAY BE INTERRUPTED BY TOUCHING INSIDE
THE BOX IN THE LOWER LEFT CORNER OF THE SCREEN, WHENEVER THE TP LIGHT IS
ON.

PRESS RETURN TO START THE TEST.
PRESS 'S' TO STOP.

?S

Press RETURN to continue.
```

Figure 29. Memory for Sequence Test

```
                    SOUND RECOGNITION TEST
                    **********************

DO YOU WANT INSTRUCTIONS Y OR N
?Y
INSERT AUDIO TAPE NO.7
INSERT SLIDE TRAY NO.7/8

   THE TEST FOR SOUND RECOGNITION MEASURES THE CHILD'S ABILITY TO
IDENTIFY A FAMILAR WORD WHEN HE HEARS IT BROKEN INTO THE PHONEMES OR
SOUNDS OF THE WORD.  THIS IS A TYPE OF AUDITORY BLENDING TASK.  THIS
TEST CONSISTS OF A TRAINING AND A TESTING SECTION.  DURING TRAINING THE
CHILD IS ASKED TO POINT TO THE PICTURE ON THE SCREEN THAT REPRESENTS THE
WORD HE HAS HEARD FROM THE AUDIO TAPE.  FEEDBACK WILL BE GIVEN FOR
INCORRECT RESPONSES AND A NEW ITEM WILL BE PRESENTED ONLY AFTER A
CORRECT RESPONSE IS MADE ON THE PREVIOUS ITEM.  THE PURPOSE OF THE
TRAINING IS TO ENSURE THAT THE CHILD IS ABLE TO IDENTIFY ALL THE
PICTURES THAT WILL SUBSEQUENTLY APPEAR IN THE TEST.  TRAINING CONSISTS
OF 28 ITEMS.
   IN THE TESTING SECTION THE CHILD WILL HEAR THE SEQUENCE OF PHONEMES
THAT MAKE A WORD, EXAMPLE  C-A-T.  THE TASK IS TO POINT TO THE PICTURE
THAT REPRESENTS THE SOUND SEQUENCE.  30 SOUND SEQUENCES REPRESENTING
FAMILAR WORDS CONSITUTE THE TEST.  THE CHILD'S TEST RESULTS ARE
AVAILABLE AT THE COMPLETION OF THE TEST.
   ADJUST THE VOLUME OF THE TAPE PLAYER SO THE AUDIO PLAYS AT A
COMFORTABLY LOUD LEVEL. THE TEST MAY BE INTERRUPTED BY TOUCHING INSIDE
THE BOX IN THE LOWER LEFT CORNER OF THE SCREEN, WHENEVER THE TP LIGHT IS
ON.

PRESS RETURN TO CONTINUE.
PRESS 'S' TO STOP.

?S

Press RETURN to continue.
```

Figure 30. Sound Recognition Test

available for each of the children on the computer file. This profile, or report, is suitable for inclusion in the child's education or medical file and is of the type normally written by the speech pathologist or special education consultant when a standard assessment procedure has been administered. A sample profile appears as Fig. 35. The first page of the profile report states background information about the child and illustrates in visual profile format his abilities in each of the auditory skill areas assessed. A description of the child's behaviour during administration of each of the tests appears on page 2. This allows anyone reading the report to subjectively evaluate the validity of the test results in terms of what they know about the child's behaviour. Page 3 continues with an outline and an interpretation of the testing results in usual report format. This section is composed automatically by the computer on the basis of 15 variables from information about each child that is stored in the computer file. This report mentions who referred the child for assessment and for what reasons auditory skills assessment was indicated. Subjective impressions of the child's speech and expres-

```
                    SOUND-SYMBOL ASSOCIATION
                    ************************

DO YOU WANT INSTRUCTIONS Y OR N
?Y
INSERT AUDIO TAPE NO. 8
INSERT SLIDE TRAY NO. 7/8


   THIS TEST ASSESSES THE CHILD'S ABILITY TO LEARN ASSOCIATIONS BETWEEN
UNFAMILAR AUDITORY AND VISUAL STIMULI. VARIOUS SYMBOLS ARE PRESENTED ON
THE SCREEN, PAIRED WITH AUDIO MESSAGES GIVING THE SYMBOLS NONSENSE
NAMES. THE TASK IS THEN TO POINT TO THE SYMBOL NAMED FROM A SET OF
SIMILAR SYMBOLS. TEN SOUND-SYMBOL ASSOCIATIONS ARE INTRODUCED TO THE
CHILD THROUGHOUT THE TEST. TEST RESULTS ARE AVAILABLE IMMEDIATELY
FOLLOWING COMPLETION OF THE TEST.
   ENCOURAGE THE CHILD TO GUESS IF NECESSARY, BUT REFRAIN FROM OTHER
CONVERSATION. ADJUST THE VOLUME OF THE TAPE SO THAT THE CHILD HEARS THE
AUDIO MESSAGES AT A COMFORTABLY LOUD LEVEL. THE TEST MAY BE INTERRUPTED
BY TOUCHING INSIDE THE BOX IN THE LEFT CORNER OF THE SCREEN, WHENEVER
THE TP LIGHT IS ON.

          PRESS RETURN TO START TEST
   OR     PRESS S TO STOP


?S

Press RETURN to continue.
```

Figure 31. Sound-Symbol Association Test

```
                AUDITORY SELECTIVE ATTENTION TEST
                *********************************

DO YOU WANT INSTRUCTIONS Y OR N
?Y
INSERT AUDIO TAPE NO. 9
INSERT SLIDE TRAY NO. 9A
HAVE READY SLIDE TRAY NO. 9B

   THIS TEST FOR SELECTIVE ATTENTION IS DESIGNED TO MEASURE THE CHILD'S
SKILL IN HEARING AUDITORY MESSAGES EMBEDDED IN NOISE OF INCREASING
INTENSITY.  THIS TEST CONSISTS OF A TRAINING AND A TESTING SECTION.
DURING TRAINING THE CHILD WILL BE GIVEN FEEDBACK FOR AN INCORRECT
RESPONSE, AND A NEW ITEM IS PRESENTED ONLY AFTER A  CORRECT TOUCH IS
MADE ON THE LAST ITEM. THE PURPOSE OF THE TRAINING SECTION IS TO ASSURE
THAT THE CHILD IS ABLE TO IDENTIFY ALL THE PICTURES THAT WILL
SUBSEQUENTLY APPEAR IN THE TEST.THE TRAINING SECTION CONSISTS OF 32
ITEMS WHILE THE TEST CONSISTS OF 110 ITEMS.
   THE CHILD'S TEST RESULTS ARE AVAILABLE AT THE END OF THE TESTING
SESSION.
   THE VOLUME OF THE TAPE PLAYER SHOULD BE ADJUSTED SO THE CHILD HEARS
THE AUDIO MESSAGES AT A COMFORTABLY LOUD LEVEL. THE TEST MAY BE
INTERRUPTED BY TOUCHING INSIDE THE BOX IN THE LOWER LEFT CORNER OF THE
SCREEN WHENEVER THE TP LIGHT IS ON.

PRESS RETURN TO CONTINUE.
PRESS 'S' TO STOP.

?S
```

Figure 32. Auditory Selective Attention Test

```
          TYPE       T,P,M,E,A,X,R,C
   OR     TYPE       H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?C
DO YOU WANT A LISTING OF CHILDREN ON THE RESTART FILE Y OR N
?Y

      1:   TLM261059    6
      2:   TLM261059    5
      3:   JJC171171    1
      4:   JJE191272    8 81 120
      5:   AOX100276    1
      6:   DEL120173    5 81 120
      7:   JJC171171    6
      8:   TOB050875    7
      9:   JJC171171    7
     10:   JJC171171    8
     11:   JJC171171    4
     12:   AEP310869    8
     13:   JJC171171    5
     14:   JSJ050575    1
     15:   JSJ050575    8
     16:   JSJ050575    4
     17:   JSJ050575    5
     18:   JSJ050575    6
     19:   JSJ050575    7
     20:   JSJ050575    9
ENTER THE CHILD'S ID CODE.
?JSJ050575
ID CODE = JSJ050575

          TYPE THE NUMBER OF THE TEST TO BE ADMINISTERED
     OR   TYPE H FOR A LISTING OF AVAILABLE TESTS
     OR   TYPE S TO STOP.
```

Figure 33. Continue mode

```
          TYPE       T,P,M,E,A,X,R,C
   OR     TYPE       H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?M

IF YOU WANT TO CHANGE A CHILD'S REGISTRATION DATA     TYPE C
IF YOU WANT TO DELETE A CHILD'S REGISTRATION DATA     TYPE D
IF NEITHER                                           TYPE S

?C
ENTER CHILD'S ID CODE
?JSJ050575
DO YOU WANT A LISTING OF THE REGISTRATION DATA? Y OR N
?N
ENTER QUESTION NUMBER
?6
 6:WHAT IS THE CHILD'S GRADE LEVEL
         FOR PRESCHOOL TYPE P
         FOR KINDERGARTEN TYPE K
         FOR GRADES 1 TO 13, TYPE THE APPROPRIATE NUMBER.

?5
5
DO YOU WANT TO CHANGE ANY MORE REGISTRATION DATA? Y OR N
?N
```

Figure 34. Maintenance mode

THE GOLDMAN-FRISTOE-WOODCOCK AUDITORY SKILLS TEST BATTERY

ADAPTED FOR COMPUTER ASSISTED ADMINISTRATION
WITH PERMISSION TO DR. E. PRESSMAN FROM
AMERICAN GUIDANCE SERVICE INC.

A: PATIENT INFORMATION

NAME**********[redacted]KEVIN
AGE AT FIRST
ASSESSMENT***** 7 YEARS 3 MONTHS
SEX**********MALE
GRADE**********2

SCHOOL*********[redacted]
REFERRED BY****MISS [redacted]
TESTED BY******C MCINTOSH

ID**********KPB191073
DATE OF FIRST
ASSESSMENT**********100281
FIRST LANGUAGE******ENGLISH

NUMBER OF
TESTING SESSIONS****6
BOARD OF EDUCATION**CARLETON

B: AUDITORY SKILLS TEST BATTERY PROFILE: PERCENTILE SCORES

	1 2 5 10 20 30 40 50 60 70 80 90 95 98 99	A.E.	T.A.
DIAGNOSTIC DISCRIM.	*	5- 1	7- 4
RECOGN. MEMORY	**********	7- 7	7- 4
CONTENT MEMORY	*	4- 6	7- 4
SEQUENCE MEMORY	**********	6-11	7- 3
SOUND RECOGN.	**********	8- 8	7- 4
SOUND-SYMB ASSOC.	**********	8- 0	7- 4
SELECTIVE ATTENTION	**********	6- 7	7- 4

* A.E. REFERS TO AGE EQUIVALENT IN YEARS AND MONTHS.
T.A. REFERS TO THE CHILD'S AGE AT TEST ADMINISTRATION IN YEARS AND MONTHS.
** INDICATES THE MAXIMUM AGE EQUIVALENT SCORE FOR THE TEST.

Figure 35. Profile record report

C.REPORT SUMMARY

TEST ADMINISTRATION

THE RECEPTIVE LANGUAGE TESTS ADMINISTERED AND THE CHILD'S BEHAVIOR DURING TESTING WAS AS FOLLOWS:

AUDITORY DISCRIMINATION I***	INTERESTED IN THE TASK
	AT EASE WITH EXAMINER
	AT EASE WITH THE EQUIPMENT
	ABLE TO WORK WELL ON HIS/HER OWN
	AWARE OF HIS/HER PERFORMANCE
AUDITORY MEMORY FOR RECOGNITION**********	ATTENTIVE
	INTERESTED IN THE TASK
	AT EASE WITH EXAMINER
	AT EASE WITH THE EQUIPMENT
	ABLE TO WORK WELL ON HIS/HER OWN
	AWARE OF HIS/HER PERFORMANCE
AUDITORY MEMORY FOR CONTENT**********	NONATTENTIVE,DISTRACTIBLE
	INTERESTED IN THE TASK
	AT EASE WITH EXAMINER
	AT EASE WITH THE EQUIPMENT
	REQUIRING MUCH ASSISTANCE AND ENCOURAGEMENT
	UNAWARE OF CORRECT AND INCORRECT RESPONSES
AUDITORY MEMORY FOR SEQUENCE**********	ATTENTIVE
	INTERESTED IN THE TASK
	AT EASE WITH EXAMINER
	AT EASE WITH THE EQUIPMENT
	ABLE TO WORK WELL ON HIS/HER OWN
SOUND RECOGNITION**********	ATTENTIVE
	INTERESTED IN THE TASK
	AT EASE WITH EXAMINER
	AT EASE WITH THE EQUIPMENT
	ABLE TO WORK WELL ON HIS/HER OWN
SOUND-SYMBOL ASSOCIATION****	ATTENTIVE
	INTERESTED IN THE TASK
	AT EASE WITH EXAMINER
	AT EASE WITH THE EQUIPMENT
	ABLE TO WORK WELL ON HIS/HER OWN
	AWARE OF HIS/HER PERFORMANCE
SELECTIVE ATTENTION*********	ATTENTIVE
	AT EASE WITH EXAMINER
	AT EASE WITH THE EQUIPMENT
	REQUIRING MUCH ASSISTANCE AND ENCOURAGEMENT

A PROFILE OF KEVIN'S TEST RESULTS APPEARS ON PAGE ONE AND THE DETAILS OF THE TEST SCORES APPEAR ON THE FOLLOWING PAGES OF THIS REPORT.

Figure 35. Continued

BACKGROUND INFORMATION

KEVIN [redacted] AGED 7 YEARS 3 MONTHS, WAS REFERRED FOR EVALUATION BY MISS [redacted] THE PRESENTING PROBLEM WAS DESCRIBED AS: RESEARCH STUDY .

SPEECH APPEARED APPARENTLY APPROPRIATE FOR HIS/HER AGE. GENERAL EXPRESSIVE SKILL IN THE ENGLISH LANGUAGE IS BEST DESCRIBED AS APPARENTLY APPROPRIATE DEVELOPMENT FOR HIS/HER AGE.

INTERPRETATION AND RECOMMENDATIONS

KEVIN DEMONSTRATED NO DIFFICULTY WITH EXPRESSIVE SPEECH AS NOTED DURING THE TESTING SESSION. ON FORMALIZED RECEPTIVE LANGUAGE TESTING KEVIN ATTAINED A NORMAL LEVEL OF PERFORMANCE FOR AGE IN TESTS OF AUDITORY MEMORY FOR RECOGNITION, AUDITORY MEMORY FOR SEQUENCE, SOUND-SYMBOL ASSOCIATION, AND SELECTIVE ATTENTION. AUDITORY MEMORY FOR RECOGNITION IS THE SHORT TERM MEMORY FOR AUDITORY EVENTS IN THE IMMEDIATE PAST. MEMORY FOR SEQUENCE REFERS TO THE CHILD'S SKILL IN REMEMBERING THE ORDER OF ELEMENTS IN AN AUDITORY EVENT . SOUND-SYMBOL ASSOCIATION REFERS TO THE CHILD'S SKILL IN LEARNING ASSOCIATION OF UNFAMILIAR AUDITORY AND VISUAL SYMBOLS (NONSENSE WORDS AND DESIGNS). SELECTIVE ATTENTION MEASURES THE ABILITY TO ATTEND AND PERCEIVE UNDER INCREASINGLY DIFFICULT LISTENING CONDITIONS OF VARIOUS COMPLETING SOUNDS.

ABOVE AVERAGE ABILITY WAS DEMONSTRATED IN THE SOUND RECOGNITION TEST. SOUND RECOGNITION MEASURES THE CHILD'S ABILITY TO ANALYZE AND SYNTHESIZE THE ISOLATED SOUNDS COMPRISING A WORD. IT IS A TYPE OF AUDITORY BLENDING.

KEVIN SHOWED PARTICULAR WEAKNESS IN THE AUDITORY DISCRIMINATION AND THE AUDITORY MEMORY FOR CONTENT SKILL AREAS, PERFORMING WELL BELOW AVERAGE FOR CHRONOLOGICAL AGE. AUDITORY DISCRIMINATION REFERS TO THE CHILD'S ABILITY TO DISTINGUISH BETWEEN HIGHLY SIMILAR SPEECH SOUNDS OR PHONEMES. AUDITORY MEMORY FOR CONTENT REFERS TO THE SKILL OF RECOGNIZING ELEMENTS OF AN AUDITORY EVENT WITHOUT REGARD FOR SEQUENCE. TRAINING IN THESE SKILL AREAS IS RECOMMENDED ALONG WITH SUBSEQUENT INVESTIGATION OF RECEPTIVE AND EXPRESSIVE LANGUAGE SKILLS. REFERRAL TO A LANGUAGE-SPEECH PATHOLOGIST IS ADVISED.

Figure 35. Continued

sive language abilities are outlined. His test results are reported in terms of the skills in which he shows normal level of performance (that is between +1 and -1 standard deviations from the mean of his age); those in which he demonstrates above average skill (greater than +1 standard deviation from the mean) and those in which the child demonstrates particular weaknesses (below -1 standard deviation from the mean). Each skill area mentioned is briefly described so that the report is meaningful to those who may be unfamiliar with auditory skills testing. Finally, training is recommended in the weak skill areas and referral to a language-speech pathologist is advised if any test scores are below average.

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AUDITORY MEMORY TESTS

	RECOGNITION	CONTENT	SEQUENCE
NUMBER CORRECT	97	4	34
PERCENTILE	51	1	42
AGE EQUIVALENT	7 YRS 7 MTHS	4 YRS 6 MTHS	6 YRS 11 MTHS
STANDARD SCORE	50	27	48
STANINE	5	1	5
DATE ADMINISTERED	250281	240281	100281
TEST DURATION(MINUTES)	15	2	5

SOUND SYMBOL TESTS

	SOUND RECOGNITION	SOUND SYMBOL ASSOCIATION
NUMBER CORRECT	29	34
PERCENTILE	78	56
AGE EQUIVALENT	8 YRS 8 MTHS	8 YRS 0 MTHS
STANDARD SCORE	58	52
STANINE	7	5
DATE ADMINISTERED	180281	170281
TEST DURATION(MINUTES)	6	20

SELECTIVE ATTENTION TEST

	QUIET	FANLIKE	CAFETERIA	VOICE	TOTAL
NUMBER CORRECT	11	30	26	28	95
PERCENTILE		95	26	28	27
AGE EQUIVALENT				6 YRS	7 MTHS
STANDARD SCORE					44
STANINE					4
DATE ADMINISTERED				190281	
TOTAL TEST DURATION					21

Figure 35. Continued

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AUDITORY DISCRIMINATION TESTS

	PART I	PARTS I+II	PARTS I+II+III
NUMBER CORRECT	87		
PERCENTILE	1		
AGE EQUIVALENT	5 YRS 1 MTHS		
STANDARD SCORE	27		
STANINE	1		
DATE ADMINISTERED	240281	NOT GIVEN	NOT GIVEN
TEST DURATION(MINUTES)	20		

SOUND CONFUSION INVENTORY

SOUND CONFUSION ERRORS IN THE INITIAL POSITION
100% ERRORS:
M/N S/Z
<100% ERRORS:
M/B V/B V/F L/Y W/L T/SH F/V P/T
SOUND CONFUSION ERRORS IN THE FINAL POSITION
100% ERRORS:
<100% ERRORS:
N/NG

DISTINCTIVE FEATURE ANALYSIS

THE SOUND DISCRIMINATION DIFFICULTIES ENCOUNTERED BY THE CHILD IN THE TEST OF AUDITORY DISCRIMINATION ARE ANALYZED FOR THEIR DISTINCTIVE FEATURES BELOW. FOR EXAMPLE, VOCALIC +/-REFERS TO PROBLEMS IN DISCRIMINATING SOUNDS THAT HAVE VOCALIC FEATURES FROM SOUNDS THAT DO NOT HAVE VOCALIC FEATURES. THE NUMBER BEFORE THE COLON IS THE NUMBER OF ERRORS THE CHILD MADE IN THIS TYPE OF DISCRIMINATION; THE NUMBER AFTER THE COLON REFERS TO THE TOTAL NUMBER OF OCCURRENCES OF THIS DISCRIMINATION IN THE TEST.

	+/-	-/+		+/-	-/+
VOCALIC	1:10	1:10	CONSONANTAL	1:10	1:10
HIGH	1:22	3:22	BACK	1:10	1:10
LOW	0: 2	0: 2	ANTERIOR	3:20	1:20
CORONAL	2:18	4:18	VOICE	1:10	3:10
CONTINUANT	1:16	1:16	NASAL	1: 4	0: 4
STRIDENT	1:14	1:14			

THE DISTINCTIVE FEATURES OF A SOUND REFER TO THOSE CHARACTERISTICS OF A SOUND WHICH REPRESENT ITS DISTINCTIVENESS AS A PHONEME. ONE (OR SEVERAL) DISTINCTIVE FEATURE CONTRASTS PROVIDE THE DISTINCTIVENESS WHICH ACCOUNTS FOR OUR ABILITY TO PERCEIVE DIFFERENT SOUNDS. ALL FEATURES ARE EITHER PRESENT(+) OR ABSENT(-) IN A PHONEME. WHEN A FEATURE IS PRESENT IN A PHONEME, THE ARTICULATORY AND ACOUSTIC CHARACTERISTICS IN THE DEFINITION ARE PRESENT.

THE FOLLOWING DEFINITIONS ARE ADAPTED FROM THOSE PROPOSED BY CHOMSKY AND HALLE IN THE SOUND PATTERNS OF ENGLISH, 1968.

Figure 35. Continued

VOCALIC: TWO CONDITIONS ARE NECESSARY FOR A SOUND TO BE LABELLED VOCALIC: THE CONSTRICTION IN THE ORAL CAVITY CANNOT BE GREATER THAN THAT REQUIRED FOR THE /I/ AND /U/, AND THE VOCAL CORDS MUST BE POSITIONED TO ALLOW SPONTANEOUS VOICING. VOCALIC SOUNDS INCLUDE THE VOWELS AND THE /R/ AND /L/ CONSONANTS. (NEGATIVE: NONVOCALIC)

HIGH: IN THE HIGH FEATURE, THE BODY OF THE TONGUE IS RAISED ABOVE THE NEUTRAL POSITION. THE SOUNDS WITH A HIGH FEATURE INCLUDE THE /W/, /J/, /K/, /G/, "CH", "J", "SH", "NG", AND SEMIVOCALIC SOUNDS. (NEGATIVE: NONHIGH)

LOW: IN THE LOW FEATURE THE BODY OF THE TONGUE IS LOWERED BELOW THE NEUTRAL POSITION. THE ONLY CONSONANT PRODUCED WITH THIS FEATURE IS /H/. SOME VOWELS AND DIPTHONGS ARE LOW. (NEGATIVE: NONLOW)

CORONAL: IN CORONAL SOUNDS THE BLADE OF THE TONGUE IS RAISED FROM THE NEUTRAL POSITION. THE CORONAL FEATURE IS INCLUDED IN THE /R/, /L/, /T/, /D/, /N/, /S/, /Z/, "TH" UNVOICED, "TH*" VOICED,"CH", "J", AND "SH". (NEGATIVE: NONCORONAL)

CONTINUANT: IN A CONTINUANT SOUND A PARTIAL OBSTRUCTION TO THE AIRFLOW IS PRESENT IN THE VOCAL TRACT, AND THE SOUNDS LAST FOR A CONTINUING TIME PERIOD. (NEGATIVE: NONCONTINUANT)

STRIDENT: A STRIDENT SOUND IS CHARACTERIZED BY NOISINESS WHICH IS PRODUCED WHEN AIR IS PASSED OVER A ROUGH SURFACE AT THE NECESSARY RATE OF FLOW AND ANGLE OF INCIDENCE. THE PHONEMES ARE /F/, /V/, /S/, /Z/, "SH", "CH", AND "J". (NEGATIVE: NONSTRIDENT)

CONSONANTAL: CONSONANTAL SOUNDS ARE MADE WITH A NARROW CONSTRICTION AS IN THE FRICATIVE CONSONANTS. ALL LIQUIDS, NASAL CONSONANTS AND NONNASAL CONSONANTS HAVE THIS FEATURE. CONSONANTS INCLUDE THE /R/, /L/, /P/, /B/, /F/, /V/, TH(UNVOICED), TH*(VOICED), /T/, /D/, "SH", "J", /N/, /M/, /S/, /Z/, AND "NG". (NEGATIVE: NONCONSONANTAL)

BACK: WHEN THE BODY OF THE TONGUE IS RETRACTED FROM THE NEUTRAL POSITION, THE SOUND INCLUDES A BACK FEATURE. THE SOUNDS PRODUCED WITH THIS FEATURE ARE THE /W/, /K/, /G/, "NG" SOUNDS, AND SOME VOCALIC SOUNDS. (NEGATIVE: NONBACK)

ANTERIOR: THE ANTERIOR FEATURE IS PRESENT WHEN A SOUND IS PRODUCED IN THE FRONT REGION OF THE MOUTH IN FRONT OF WHERE THE "SH" SOUND IS PRODUCED. THESE SOUNDS ARE THE /L/, /P/, /B/, /F/, /V/, /M/, /T/, /D/, /N/, /S/, /Z/, "TH" UNVOICED, AND "TH*" VOICED. (NEGATIVE: NONANTERIOR)

VOICED: IN VOICED SOUNDS THE VOCAL CORDS ARE VIBRATING. (NEGATIVE: NON-VOICED)

NASAL: WHEN THE VELUM IS LOWERED TO ALLOW THE AIR TO BE DIRECTED THROUGH THE NOSE, THE NASAL FEATURE IS PRESENT. THE SOUNDS WITH THIS FEATURE INCLUDE THE /M/, /N/, AND "NG". (NEGATIVE:NONNASAL)

Figure 35. Concluded

```
          TYPE        T,P,M,E,A,X,R,C
   OR     TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?E
DO YOU WANT INSTRUCTIONS Y OR N
?N

IF YOU WANT A LISTING OF ALL CHILDREN ON FILE,TYPE A FOR ALL.
IF YOU WANT A LISTING FOR A GROUP OF CHILDREN,TYPE G FOR GROUP.
IF YOU WANT A LISTING FOR AN INDIVIDUAL CHILD,TYPE I FOR INDIVIDUAL.
IF NEITHER, TYPE S FOR STOP.

?I
ENTER THE CHILD'S LAST NAME.
?[redacted]
  THE COMPUTER IS SEARCHING AND MAY TAKE A WHILE

    1:  SUSIE [redacted]0G160273

        TEST      TA      AE     GR  S  PR  SS  ST   NC
         1       7- 9    9- 5   2   2  72  56   6   97
         4       7-11   11- 8   2   2  84  60   7  105
         5       7- 9    7- 4   2   2  38  47   4   18
         6       7-11    8- 3   2   2  55  51   5   42

         7       7- 9    8- 8   2   2  72  56   6   29
         8       7- 9   14- 0   2   2  99  73   9   53
         9       7-11    5- 4   2   2   1  27   1   88

 DO YOU WANT TO DO ANOTHER SEARCH Y OR N
?N
```

Figure 36. Enquiry mode

Detailed test results, including raw score transformations based on the norms reported by Goldman, Fristoe and Woodcock, appear on page 4 for the three memory tests, two sound-symbol tests and for the test of selective attention. Pages 5 and 6 report detailed test results for the children's files.

A child's file may be accessed with his last name in ENQUIRY mode only, in case an ID code has been misplaced or forgotten, as in Fig. 36. Figure 37 is an account of the instructions available in ENQUIRY mode and how search criteria are selected for retrieving selected groups of children. The output from ENQUIRY mode includes names, ID codes and a listing of the tests administered to each child.

```
DO YOU WANT A LISTING OF THE SEARCH CRITERIA THAT YOU HAVE SELECTED Y OR N
?Y
CRITERION 5.000
 5:SCHOOL
    TYPE THE SCHOOL NAME EXACTLY AS IT APPEARS IN THE ATTACHED BOOKLET.
    IF THE CHILD DOES NOT ATTEND SCHOOL, TYPE NONE.

BELLS CORNERS

DO YOU WANT TO ALTER YOUR SEARCH CRITERIA Y OR N
?Y
ENTER CRITERION NUMBER OR PRESS RETURN
?8
CRITERION 8.000:
 8:EXAMINER
    PLEASE TYPE THE INITIAL AND LAST NAME
    DO NOT USE A PERIOD AFTER THE INITIAL.

?J CUNNINGHAM
YOU HAVE MADE THE FOLLOWING SELECTION:
J CUNNINGHAM
DO YOU WANT TO DO ANOTHER ALTERATION Y OR N
?N
DO YOU WANT A LISTING OF THE SEARCH CRITERIA THAT YOU HAVE SELECTED Y OR N
?Y
CRITERION 5.000
 5:SCHOOL
    TYPE THE SCHOOL NAME EXACTLY AS IT APPEARS IN THE ATTACHED BOOKLET.
    IF THE CHILD DOES NOT ATTEND SCHOOL, TYPE NONE.

BELLS CORNERS

CRITERION 8.000
 8:EXAMINER
    PLEASE TYPE THE INITIAL AND LAST NAME
    DO NOT USE A PERIOD AFTER THE INITIAL.

J CUNNINGHAM

DO YOU WANT TO ALTER YOUR SEARCH CRITERIA Y OR N
?N
  THE COMPUTER IS SEARCHING AND MAY TAKE A WHILE


          TYPE        T,P,M,E,A,X,R,C
   OR     TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?E
DO YOU WANT INSTRUCTIONS Y OR N
?Y
   ENQUIRY MODE PROVIDES A LIST OF NAMES, ID CODES, AND THE AUDITORY SKILLS
TESTS ADMINISTERED TO REGISTERED CHILDREN. THE INFORMATION MAY BE RETRIEVED FOR
A SINGLE CHILD, FOR A GROUP OF CHILDREN, OR FOR ALL CHILDREN REGISTERED.
INFORMATION FOR AN INDIVIDUAL CHILD INCLUDES DETAILED TEST RESULTS AS WELL AS A
LISTING OF TESTS ADMINISTERED AND MAY BE REQUESTED BY TYPING THE CHILD'S LAST
NAME.
   LISTINGS FOR GROUPS OF CHILDREN ARE OBTAINED BY A COMPUTER SEARCH OF 12
CRITERIA FROM INFORMATION COLLECTED IN REGISTRATION MODE. THE CRITERIA AVAILABLE
FOR SELECTION ARE:
```

Figure 37. Enquiry mode criteria

```
 1 LAST NAMES                  7 CITY
 2 AGE IN YEARS                8 EXAMINER
 3 SEX                         9 REFERRING PERSON
 4 GRADE LEVEL                10 FIRST LANGUAGE
 5 SCHOOL                     11 SPEECH
 6 BOARD OF EDUCATION         12 EXPRESSIVE LANGUAGE SKILL

   TYPE THE VALUE FOR EACH CRITERION AS IT IS NAMED. MORE THAN ONE VALUE MAY BE
ENTERED. SEPARATE MULTIPLE VALUES BY A COMMA. FOR EXAMPLE, FOR AGES 4-7 TYPE
4,5,6,7. IF A CRITERION IS NOT OF INTEREST IN THE GROUP TO BE SELECTED, PRESS
THE RETURN KEY.


IF YOU WANT A LISTING OF ALL CHILDREN ON FILE,TYPE A FOR ALL.
IF YOU WANT A LISTING FOR A GROUP OF CHILDREN,TYPE G FOR GROUP.
IF YOU WANT A LISTING FOR AN INDIVIDUAL CHILD,TYPE I FOR INDIVIDUAL.
IF NEITHER, TYPE S FOR STOP.

?G
CRITERION 1.000:
1:TYPE THE LAST NAMES OF INTEREST
?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 2.000:
2:AGE AT REGISTRATION IN YEARS

?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 3.000:
 3:SEX: BOY,  TYPE 1
        GIRL, TYPE 2

?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.


THE FOLLOWING CHILDREN MATCH THE SEARCH CRITERIA:
                                                    TESTS ADMINISTERED
     1:   DEL120173                 DAWN            1, 4, 6, 7, 8, 9.
     2:   EMD060373                 EVELYN          1, 4, 5, 6, 7, 8, 9.
     3:   SOG160273                 SUSIE           1, 4, 5, 6, 7, 8, 9.
     4:   LJB170173                 LISA            1, 4, 5, 6, 7, 8, 9.
     5:   CAW141173                 CINDY           1, 4, 5, 6, 7, 8, 9.
     6:   JRT231173                 JAMIE           1, 4, 5, 6, 7, 8, 9.
     7:   AOA290773                 ANGELA          1, 4, 5, 6, 7, 8, 9.
     8:   JJE191272                 JEFF            1, 4, 5, 6, 7, 9.
     9:   SRL200972                 STEPHEN         1, 5, 6, 7, 8, 9.
    10:   BJC250773                 BRADLEY         1, 9.
    11:   ALF311274                 ALISSA          7.
    12:   JWP080973                 JASON           5, 6, 8.
 DO YOU WANT TO DO ANOTHER SEARCH Y OR N
?N

          TYPE       T,P,M,E,A,X,R,C
   OR     TYPE       H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND    PRESS THE RETURN KEY.
?X

SESSION ENDED FOR COURSE .
```

Figure 37. Concluded

```
DO YOU NEED INSTRUCTIONS Y OR N
?N


   IF YOU WANT SCORES FOR A GROUP, TYPE G
   IF YOU WANT SCORES FOR AN INDIVIDUAL CHILD, TYPE I
   IF NEITHER, TYPE S FOR STOP.

?G

     IF YOU WANT ONLY STATISTICALLY ACCEPTABLE CHILDREN, TYPE R FOR RESTRICTED.
     IF YOU WANT ALL CHILDREN SATISFYING THE SEARCH CRITERIA,TYPE A FOR ALL.
     IF NEITHER, TYPE S FOR STOP.


?A

          TYPE THE NUMBER OF THE TEST
     OR   TYPE H FOR A LISTING OF AVAILABLE TESTS
     OR   TYPE S TO STOP.

?1
CRITERION 1:
AGE AT TESTING IN YEARS
?7
YOU HAVE MADE THE FOLLOWING SELECTION:
7

CRITERION 2:
GRADE LEVEL
      FOR PRESCHOOL TYPE P
      FOR KINDERGARTEN TYPE K
      FOR GRADES 1 TO 13, TYPE THE APPROPRIATE NUMBERS.

?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 3:
SCHOOL
    TYPE THE SCHOOL NAME EXACTLY AS IT APPEARS IN THE ATTACHED BOOKLET.
    IF THE CHILD DOES NOT ATTEND SCHOOL, TYPE NONE.

?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 4:
BOARD OF EDUCATION
    TYPE THE NAME EXACTLY AS IT APPEARS IN THE ATTACHED BOOKLET.
    IF THE CHILD DOES NOT ATTEND SCHOOL, TYPE NONE.

?

THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 5:
REFERRING PERSON ( TITLE AND LAST NAME )
?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.
```

Figure 38. Analytic mode

```
CRITERION 6:
CHILD'S SEX
ENTER 1 FOR BOYS
      2 FOR GIRLS

?2
YOU HAVE MADE THE FOLLOWING SELECTION:
2

CRITERION 7:
LANGUAGE ( THE CHILD'S FIRST LANGUAGE )
?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 8:
THE CHILD'S SPEECH IS BEST DESCRIBED AS:
    ( TYPE THE RELEVANT LETTERS, FOR EXAMPLE, BCE )
          A:VIRTUALLY NONEXISTENT
          B:UNINTELLIGIBLE
          C:INTELLIGIBLE BUT WITH INCORRECT USE OF SOUNDS
          D:DISFLUENT WITH HESITATION AND ABNORMAL RATE AND RHYTHM
          E:NASAL
          F:HUSKY,HOARSE OR WHISPERY
          G:APPARENTLY APPROPRIATE FOR HIS/HER AGE

?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 9:
THE CHILD'S GENERAL EXPRESSIVE SKILL IN THE ENGLISH LANGUAGE IS BEST DESCRIBED
AS:     ( TYPE THE RELEVANT LETTERS, FOR EXAMPLE, BCF )
          A:VIRTUALLY NONEXISTENT EXPRESSIVE LANGUAGE
          B:INCLUDING SENTENCES THAT ARE SHORT IN LENGTH FOR EXAMPLE, ME GO OUT
          C: CONSISTENTLY OMITTED PARTS OF SPEECH
          D:IMMATURITY IN VERB FORMS
          E:IMMATURITY IN USE OF NEGATIVES
          F:LACKING IN VOCABULARY
          G:INCLUDING IRRELEVANT INFORMATION BUT WITH CORRECT SENTENCE STRUCTURE
          H:GENERALLY IMMATURE FOR HIS/HER AGE
          I:APPARENTLY APPROPRIATE DEVELOPMENT FOR HIS/HER AGE

?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 10:
RANGE OF PERCENTILE RANKS
ENTER SMALLER PERCENTILE RANK OF INTEREST
?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 11:
RANGE OF AGE EQUIVALENT YEARS
ENTER SMALLER AGE EQUIVALENT YEAR OF INTEREST
?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

CRITERION 12:
RANGE OF STANDARD SCORES
ENTER SMALLER STANDARD SCORE OF INTEREST
?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.
```

Figure 38. Continued

```
CRITERION 13:
RANGE OF STANINES
ENTER SMALLER STANINE OF INTEREST
?
THIS CRITERION WILL NOT BE USED IN THE SEARCH.

DO YOU WANT A LISTING OF THE SEARCH CRITERIA THAT YOU HAVE SELECTED Y OR N
?N
DO YOU WANT TO ALTER YOUR SEARCH CRITERIA Y OR N
?N
```

AUDITORY DISCRIMINATION I

THE COMPUTER IS SEARCHING AND MAY TAKE A WHILE

THE FOLLOWING CHILDREN MATCH THE SEARCH CRITERIA:

GROUP DATA

			TA	AE	GR	S	PR	SS	ST	NC
1:	CLA260473	CINDY	7- 1	5- 5	1	2	4	32	1	89
2:	SLK291272	SHELLY	7- 6	5-10	2	2	12	38	3	91
3:	DEL120173	DAWN	7-11	12- 2	2	2	83	60	7	98
4:	EMD060373	EVELYN	7- 9	9- 5	2	2	72	56	6	97
5:	SOG160273	SUSIE	7- 9	9- 5	2	2	72	56	6	97
6:	LEH140573	LOUISE	7- 6	6-10	2	2	35	46	4	94
7:	LJB170173	LISA	7- 9	9- 5	2	2	72	56	6	97
8:	CAW141173	CINDY	7- 1	7- 4	2	2	45	49	5	95
9:	FAA250773	FAY	7- 3	7- 4	2	2	45	49	5	95
10:	AOA290773	ANGELA	7- 4	7- 4	2	2	45	49	5	95

*TA REFERS TO THE CHILD'S AGE IN TESTING IN YEARS AND MONTHS
AE REFERS TO THE CHILD'S AGE EQUIVALENCE IN YEARS AND MONTHS
GR REFERS TO THE CHILD'S GRADE IN SCHOOL
S REFERS TO THE CHILD'S SEX
PR REFERS TO THE CHILD'S PERCENTILE RANK IN HIS/HER AGE GROUP
SS REFERS TO THE CHILD'S STANDARD SCORE
ST REFERS TO THE CHILD'S STANINE
NC REFERS TO THE CHILD'S NUMBER OF CORRECT RESPONSES.

```
NUMBER OF CHILDREN IN THE GROUP= 10.000
MEAN OF PERCENTILE RANKS        = 48.500
STANDARD DEVIATION              = 25.255

MEAN OF NUMBER CORRECT          = 94.800
STANDARD DEVIATION              = 2.712

MEAN OF STANDARD SCORE          = 49.100
STANDARD DEVIATION              = 8.287
```

Figure 38. Concluded

```
ITEM ANALYSIS
-------------

     1=CORRECT, 2=INCORRECT, 0=NO ANSWER


                          1         2         3         4         5
                 12345678901234567890123456789012345678901234567890
                 --------------------------------------------------
 1:   CLA260473  11111111111121111111111111101121111110111111111111
 2:   SLK291272  11101211001111110111111111111110111111111111111111
 3:   DEL120173  11111111111111111111111111111111111111111111111111
 4:   EMD060373  11111111111121111112111111111111111111111111111111
 5:   S0G160273  11111111111111111111111111111111111111111111111110
 6:   LEH140573  12111111111121111211101111111111111111111111111111
 7:   LJB170173  12111111111111111111111112111111111111111111111111
 8:   CAW141173  11111111111111111121111111111111101111111111111111
 9:   FAA250773  11111111111111111111111111111111111111111121111111
10:   A0A290773  11111111111121111112111111111111111111111112111111


                             6         7         8         9         0
                 12345678901234567890123456789012345678901234567890
                 --------------------------------------------------
 1:   CLA260473  11111111111111101111211111211111211211111101111211
 2:   SLK291272  11111111111111111112111111111111111111111111121211
 3:   DEL120173  11111111111111111101111112111111111111111111111111
 4:   EMD060373  11211111111111111111111111111111111111111111111111
 5:   S0G160273  11111111111111122111111111111111111111111111111111
 6:   LEH140573  11111111111111111121111111111111111111111111111121
 7:   LJB170173  11111111111111111111111111111111111111111111111111
 8:   CAW141173  11111111111111121111111111111111111111111111111111
 9:   FAA250773  11111111111110121111111112111111111111101111111121
10:   A0A290773  11111111111111111111111111111111111120111111111111
DO YOU WANT TO DO  ANOTHER SEARCH Y OR N
?Y
```

Figure 39. Item analysis: Analytic mode

Analytic Mode

Detailed test results and basic statistics are available for selected groups of children in ANALYTIC mode. Figure 38 illustrates instructions available for this mode and how search criteria are established for the selected group of children. The output of this mode includes each child's raw score, transformation of this score based on the Goldman-Fristoe-Woodcock norms and average scores for the particular group of children selected. An item analysis of the test results is also available which indicates each child's responses to each test item. These features are evident in Fig. 39. This information is also available for individual children as is shown in Fig. 40.

Exit Mode

This mode of the ASB program simply allows the user to terminate use of the program by typing X.

```
            TYPE        T,P,M,E,A,X,R,C
   OR       TYPE        H FOR HELP TO GET AN EXPLANATION OF THE LETTERS.
   AND      PRESS THE RETURN KEY.
?A




DO YOU NEED INSTRUCTIONS Y OR N
?N


   IF YOU WANT SCORES FOR A GROUP, TYPE G
   IF YOU WANT SCORES FOR AN INDIVIDUAL CHILD, TYPE I
   IF NEITHER, TYPE S FOR STOP.

?I
ENTER THE CHILD'S ID CODE.
?SLK291272
STUDENT ID = SLK291272
  THE COMPUTER IS SEARCHING AND MAY TAKE A WHILE


        TYPE THE NUMBER OF THE TEST
   OR   TYPE H FOR A LISTING OF AVAILABLE TESTS
   OR   TYPE S TO STOP.

?5


        SHELLY [redacted]

        TEST      TA      AE    GR  S  PR  SS  ST   NC
         5      7- 6    7- 4   2   2  52  51   5   18


  *TA REFERS TO THE CHILD'S AGE IN TESTING IN YEARS AND MONTHS
   AE REFERS TO THE CHILD'S AGE EQUIVALENCE IN YEARS AND MONTHS
   GR REFERS TO THE CHILD'S GRADE IN SCHOOL
   S  REFERS TO THE CHILD'S SEX
   PR REFERS TO THE CHILD'S PERCENTILE RANK IN HIS/HER AGE GROUP
   SS REFERS TO THE CHILD'S STANDARD SCORE
   ST REFERS TO THE CHILD'S STANINE
   NC REFERS TO THE CHILD'S NUMBER OF CORRECT RESPONSES.


                                 11111111111111
TEST ITEM 11223344556677889900112233445566
-----------------------------------------
SCORES    11111212111111012122122222211

     1=CORRECT, 2=INCORRECT, 0=NO ANSWER
```

Figure 40. Individual item analysis: Analytic mode

CHAPTER VI

USER ACCEPTANCE OF THE AUDITORY SKILLS BATTERY SYSTEM

The advance of computer technology, as with any new technology, suffers from concern and resistance to change from many individuals unfamiliar with its use. The computer-assisted learning and testing area is slowly gaining in recognition and acceptance, although there is still concern for jobs and some reluctance to interact with a machine in any meaningful way. Computer games and TV video units have become part of our everyday life and as a result, the computer is gradually being accepted as a tool as well as a toy. The LEK 421 PLAT terminal, "Fred" as it came to be called, was generally accepted as an interesting device with amazing capabilities. However, few people, other than the many children who used the terminal, were intrigued enough to want to interact directly with the system.

User aceptance was evaluated in various school environments, in a summer camp setting, in a hospital clinic setting and through many demonstrations to professionals interested in the area of speech and in computer-assisted assessment.

The Speech/Language Pathologist

The computerized ASB was presented to people in the profession of speech/language pathology at formal and informal demonstrations in the Speech and Language Department of the Children's Hospital of Eastern Ontario and at various professional meetings including the American, the Canadian and the Ontario Speech and Hearing Associations. The general impression of these professionals was that the ASB was an interesting method for assessing auditory skills. Many therapists indicated that the regular G-F-W assessments provided much relevant information about a child's skills, but that the length of these tests often precluded their use. It was suggested that ASB assessments be completed and the report be made available to the therapist before he or she first saw the child. Subsequent assessment could then be made based on the results of preliminary ASB testing. The ASB program was designed for ease of administration by a non-professional person. No knowledge of speech and language development or computer expertise is necessary. It is, therefore, appropriate for administration by a speech technician, student or even a volunteer.

A number of speech and language therapists agreed to actually conduct testing with ASB program themselves. They were pleased with the relative ease of administration of the tests under computer control and found that this allowed them to direct their attention to how the child was responding during the test. Some therapists felt that they gained valuable information in this way that they would not have been able to collect if they had to be concerned about administering test items and

scoring the child's rsponses in the standard test administration.

Report writing is a major responsibility of the speech and language therapists. All therapists appreciated the ASB report that is printed out automatically from the computer after assessments have been completed. Of particular interest were the automatic transformation of the child's raw scores to age equivalent and percentile scores, the computerized interpretation of these scores, and the distinctive features analysis of any sound confusions made by the child.

Some professionals who attended demonstrations of the ASB expressed concern about the mechanization and depersonalization of computer-assisted assessment. Others made nervous statements about their jobs being taken over by computers. These are very common concerns which are evident with the introduction of any new technology. These individuals were easily assured with further discussion about the usefulness of computer technology as a tool which will enable the therapist to more easily provide more intensive diagnostic and prescriptive information about a child's language development.

The Nonprofessional

The ASB program was used by a number of university students during the course of pilot testing and data collection for this evaluation. These students were from an undergraduate program in linguistics and volunteered some of their time in return for experience relevant to their interests.

These nonprofessional users adapted to the computerized assessment procedure very well. They learned quickly how to interact with the computer through the terminal, how to use the ASB program for assessing a child and for retrieving test results, and how to deal with hardware and software problems which occurred with frequency during the early stages of development. They were able to make the testing sessions fun and interesting for the children. Eight of these students worked with the system part time over the course of four months. Of particular concern was whether or not they could run the ASB program without making a mistake that would result in invalid test results or the loss or deletion of test scores due to improper interaction with the computer. No such instances occurred.

Following their involvement with the ASB system, the students were asked to complete a brief questionnaire about their experiences, as an attempt to evaluate the feasibility of this system for use by individuals who are relatively naive to auditory skills testing and who had virtually no experience with computers.

In general, these users evaluated the ASB system very positively with some concerns expressed about the reliability of the hardware and about the speed of computer response in terms of being quick enough to maintain the child's attention. They also noted that although the children related well to the terminal, teachers were only moderately interested in the procedure.

Teachers

The ASB system was demonstrated to teachers in both a clinical environment and in a school setting during the course of the project. Teachers generally expressed interest in the usefulness of the ASB as an easily administered screening battery for auditory skills. They were also impressed with the detailed profile report which included an interpretation of test scores and a description of each of the auditory skill areas.

Teachers who taught in regular classrooms seemed interested only in acquiring the completed test results for individual children in their classes. However, teachers who specialized in remedial reading, special education, learning disabilities, or who taught a special class were more interested in how the ASB program functioned, the background of the tests and the usefulness of the ASB system as a tool for detailed testing. These teachers became involved in demonstrations and welcomed hands-on experience with the terminal. They frequently made positive comments and constructive recommendations and expressed hopefulness that such systems would eventually be available for routine use.

Children Users

Children from 4 to 17 years of age were involved in testing sessions with "Fred", the name used to refer to the ASB system of terminal and computer. All children appeared to enjoy the opportunity to work with the computer terminal and "Fred" developed great popularity in the schools where testing was conducted.

The children were more sophisticated about the computer hardware than many adults who interacted with the system, probably due to the great popularity of computer type toys and games today. None of the children hesitated to interact. Once they were told where to sit and heard introductory audio messages from "Fred", they followed instructions well and touched the screen immediately on request. Some of the children who worked with the terminal on several occasions became interested in how the examiner interacted with the terminal via the keyboard. Many of these youngsters learned their own computer ID code and were allowed to access their own file and set up the ASB program for the appropriate test. They seemed to enjoy this extra interaction with "Fred".

Testing sessions were set up as a game for the child to play with "Fred", and the testing sessions generally went well. There are three very long tests in the G-F-W battery, those for auditory discrimination, selective attention and recognition memory, each including over 100 test items of a very simple task with much repetition. In the very standardized automated procedure, where the task involved waiting for a slide, waiting for the audio message and then making a touch response, some children became bored. They made statements such as "Is this ever going to end?" or "How many more?". The younger children, especially

those prone to hyperactivity, were distractible in the latter portions of these tests so that their responses became more impulsive. The frequency of incorrect responses increased as did the frequency of missed touches within the time available for a response, thus lowering their test scores. It was found that distractibility in these tests could be reduced if the examiner sat close to the child and the terminal to direct the child's attention when necessary.

There were some features of the system that the children specifically liked. The fact that "Fred" talked to them was intriguing. However, some children found the earphones irritating and others were concerned that they could hear properly. They were fascinated with the fact that "Fred" could show them any slide in the slide tray and then know which picture they had touched on the screen. They expressed great concern whenever "Fred" had a problem and difficulties were encountered with the terminal or with the computer.

Often a child would ask to be given the paper printout which was output during his testing session. So that children would have something other than this data to take away with them, a brief numbers guessing game was provided which allowed the child to work with the keyboard. A hapy face was output on completion and the child was allowed to take this with him.

During the course of this feasibilty study a number of observations were made which concern how the child interacts with the touch panel. If the terminal is placed on a table of regular height and a normal chair is used, children under about 10 years of age have to reach up to touch the screen. As a result, it is often the fist of their hand rather than the pointing finger which first touches the screen and this often results in an invalid or incorrect response. A lower table or a high stool should be used so that the child can touch the screen with his finger held horizontally rather than pointing upwards. Instructions to the child to point with only one finger should also be given. Very young children may have such short fingers or poor fine motor control that they have trouble touching the screen with just a finger tip. The rubber eraser end of a pencil functions well as a pointer.

CHAPTER VII

RELIABILITY AND VALIDITY OF THE COMPUTERIZED AUDITORY SKILLS BATTERY

An important aspect of this project concerns the reliability and validity of the computer-assisted auditory skills test battery. The ASB program was designed to make use of the content of the Goldman-Fristoe-Woodcock Auditory Skills Test Battery (23). The authors report split half reliability for the G-F-W battery ranging from 0.46 to 0.97, with a median reliability of 0.85. The tests are least reliable for children 9 to 18 years of age with a median of 0.77. The median reliability for children 3 to 8 years of age was 0.87 and, for individuals over 19 years of age it was 0.90. Concern has been raised over the possible inflation of these reliability coefficients due to the wide range of the three age groups and the high correlation of G-F-W scores with age. No test-retest reliabilities are reported.

Validity is outlined in the G-F-W technical manual in terms of content and construct validity. Complete descriptions of the tasks and the auditory skills required in each test of the battery are discussed in relation to the auditory skills necessary in real life situations as an explanation of the content validity of the test battery.

Construct validity is provided with three methods. First, intercorrelations between the tests in the battery were determined, with the effects of age removed by partial correlation techniques. These intercorrelations were low, indicating that the tests measure distinctly different auditory traits or skills rather than global auditory perception ability. Second, auditory test scores were correlated with age to determine if the battery of tests reflected the developmental nature of auditory perception skills. High, positive correlations between test scores and age were found in the 3 to 8 year age range while slightly lower, positive correlations appeared in the age range 9 to 18 years. Furthermore, high and negative correlations appeared in the older (19 to 80) age group. These correlations indicate that test scores in the G-F-W battery reflect the pattern of improvement of auditory perception skills until maturity and the subsequent decline of these abilities into old age. The third method of demonstrating validity is a comparison of the scores of normal children to those of two clinical groups of children, one with mild speech or learning difficulties and the other with severe learning difficulties. Children with mild dysfunction scored lower than normal children on 9 of the 12 tests while moderately-to-severe dysfunctional individuals scored lower than normals on each test of the battery.

These data indicate that the G-F-W battery does differentiate between normal individuals and those with dysfunctional skills.

On the basis of the validity information reported in the G-F-W technical manual, and from reports of speech-language pathologists, the

computerized ASB adaptation of the G-F-W battery was considered to have adequate validity. Further evidence of the validity of the ASB was collected in the clinical trial with learning disabled children (Chapter VIII). On the other hand, the reliability of the tests, especially in terms of test-retest correlations, was of concern. In addition, it was important to determine if the computerized version of the tests yielded comparable scores to the standard G-F-W versions.

A study was designed to yield preliminary indications of the test-retest reliabilities of both the standard G-F-W and the computerized ASB tests. In addition, comparisons of ASB and G-F-W test scores were made to determine the validity of using G-F-W normative data for the transformation of raw scores derived from computerized ASB assessments.

Method

Design

This study was designed with a test-retest paradigm and four treatment groups of subjects. All subjects were tested twice on seven of the nine ASB assessments. The first group were assessed with the computerized ASB for test and retest. The second group were administered the computerized versions for the first assessment and the standard G-F-W tests for the second assessment. The third group were assessed with the G-F-W tests on the first test administration and with the computerized ASB for the retest. Finally, the fourth group received standard G-F-W test administration for both the test and the retest.

Subjects

This study was small in terms of number of subjects. Each of the four treatment groups included five children. Time factors precluded the possibility of including more children in the study. Children were chosen from grade two as this is the middle of the age-grade range for which the G-F-W assessments are routinely administered for language educational testing.

All children attended a school in a middle-class Ottawa neighbourhood. Grade two teachers at this school were asked to indicate the children who were achieving below normal for grade level, above normal and at an average level. Twenty children who were age appropriate for grade two, with no known hearing problems and whose first language was English, were chosen for the study. These children were assigned to the four treatment groups such that each group included one child who was achieving below normal, one child above normal and three at the average level of achievement. Eleven of the children were girls while nine were boys. They ranged in age from 6 years 11 months to 8 years 2 months.

Procedure

All children involved in the study were assessed with seven of the nine auditory skills tests, including auditory discrimination part I, recognition memory, memory for content, memory for sequence, sound recognition, sound symbol association and selective attention. Parts II and III of auditory discrimination were not administered as part of the study. These tests were designed for use when further diagnostic information is needed on the basis of a child's low score on part I. The computerized ASB tests were administered with the LEK 421 PLAT terminal in a lighted windowless room in the school. Children always wore the earphones. The standard G-F-W tests were administered in a similar room with a high quality Sony tape recorder-player (Model TC-150). Headphones of comparable quality to those used with the computer terminal were worn by the children for standard testing.

The testing procedure was set up as an opportunity for the children to "play with" or "work with" the computer and the tape player. Children were brought individually to the testing room for sessions of approximately 20 min at a time. In most cases, assessments of only one skill were administered in any one session. Therefore, each child was involved in 14 testing sessions throughout the four months of the study.

Approximately one month separated the first and second administration of the test for each skill. Five experimenters conducted the study, one research assistant and four undergraduate university students in linguistics. In order to control for any effects that different experimenters may have on a child's test results, one experimenter administered both assessments of a particular skill area.

Results and Discussion

All children appeared to enjoy the testing sessions. The computer terminal, "Fred", quickly became popular in the school. A brief non-testing game was developed to offer hands-on computer experience to other children from the classrooms of the children involved in this study.

Test scores (raw scores) for each of the seven ASB tests were subjected to repeat measures analysis of variance and subsequent t-tests, taking into account two test administrations and the four treatment groups:

1 automated at first testing and automated at second testing (A-A)
2 automated at first testing and standard at second testing (S-A)
3 standard at first testing and automated at second testing (S-A)
4 standard at both first and second testing (S-S)

The relatively small sample size, five subjects per group for a total of 20 children, limits the power of these statistics; however, some trends are evident.

Auditory Discrimination Part 1

No significant difference was apparent between first and second test administrations for children in both the A-A and S-S groups, suggesting that both standard and automated versions are reliable. There was a trend towards a significant interaction effect, and t-tests for the A-S and S-A group indicated that children achieved higher scores on the standard version than on the automated version ($t = 2.345$; $df = 9$; $p < 0.05$). The average difference was three points. Subjective experimenter impressions of the testing sessions suggest that children become bored with the computer-administered version of auditory discrimination. This test includes 32 training items and 100 test items, all of which require the child to do the very simple task of pointing to the picture of the word that he hears. Testing sessions lasted approximately 20 min. On each trial, the child was required to wait while the computer presented the appropriate slide and audio message. Although the computer administration took only about 1 s longer than the standard presentation per trial, neither the child nor the experimenter had any control over the speed of presentation. In the standard version, although audio messages are presented at a fixed rate via cassette tape player, it seems that the action of turning the page in the test booklet from trial to trial was sufficient to maintain the child's interest and increase his scores. Further investigation of this apparent difference in scores on automated versus standard administration would be necessary before G-F-W normative data would be appropriate to convert raw scores on the ASB to corresponding percentiles and age equivalent scores.

Selective Attention

The task presented to the child in the test for selective attention is exactly that of auditory discrimination except for a variation in background noise. Thus it is not surprising that, as was the finding with auditory discrimination, children achieved lower scores on the automated version of this test than on the standard version ($t = 3.72$; $df = 10$; $p < 0.01$). This may again be explained by the length of this relatively easy test (110 items) and the fact that with computer administration children lose attention and become fidgety and impulsive and, therefore, miss responses or make incorrect responses. This behaviour did not occur as often under standard administration. No differences were apparent between first and second administrations of this test indicating that each version is reliable in itself.

Recognition Memory

Analysis of variance indicated that there were no significant differences between scores on first and second administrations of this test and between the automated and standard versions. These results suggest adequate reliability and the appropriateness of using G-F-W normative data for the transformation of ASB scores.

Memory for Content

Analysis of variance of scores on this test yielded no significant main effects. However, there was a trend towards a significant interaction ($F = 2.64$; $df = 3,15$; $p = 0.08$) which suggested that for children in the A-A group, the second automated administration produced higher test scores than the first, and that for children in the S-S group, the second standard administration resulted in lower scores than the first. It is suggested that this finding is an artifact and results from the variability in test scores apparent from the small number of subjects. Further study would be necessary to confirm the test-retest reliability of both automated and standard versions of this test. No overall difference occurred when automated test scores were compared to standard test scores; however, the suspect reliability of the test may confound this apparent congruence.

Memory for Sequence

Analysis of variance of the test indicated a significant practice effect ($F = 5.23$; $df = 1.16$; $p < 0.05$). For both automated and standard versions children score higher on the second administration of the test than on the first administration. In this test, the child is required to point to pictures in the same sequence that they were presented to him auditorily. There appears to be some learning of the skills required for this task as a result of the test. Therefore, test-retest reliability, at least over a period of one month, is poor.

No significant difference was evident between scores on the automated and standard versions of this test. Therefore, at least for initial administration G-F-W normative data would be appropriate for use with ASB raw scores.

Sound Recognition

No significant differences are apparent in the test of sound recognition between first and second testing or between automated and standard test administration. Although there was a trend towards an interaction effect ($F = 2.92$; $df = 3,16$; $p = 0.06$) inspection of the raw data indicated that this can be explained by one child's particularly low score at one testing session. This individual variability is not likely significant. Therefore, adequate test-retest reliability is apparent for

the test of sound recognition and G-F-W norms are appropriate for use with ASB test scores.

Sound-Symbol Association

A significant improvement in test scores between the first and second administrations of this test was found for both the standard and automated version ($F = 37.27$; $df = 3,15$; $p = 0.001$). This is not a surprising finding as the test is designed to measure the child's ability to learn sound-symbol associations. Children are able to remember some of these associations at least over the one month interval between the first and second testing sessions. No significant difference was apparent between test scores on the standard and automated versions. Therefore, ASB raw test scores may be transformed with the use of G-F-W normative data.

Summary

In summary, adequate test-retest reliability is indicated for both standard and automated versions of auditory discrimination, selective attention, recognition memory and sound recognition. No conclusion may be drawn for memory for content, and test scores over a period of one month definitely improve for tests of memory for sequence and sound symbol association. These results may be suspect due to the small number of subjects in this study. Further investigation is necessary to yield adequate test-retest reliability data.

The second concern of this study was the validity of using G-F-W normative data, from standard test administration procedures, to transform raw scores from the computerized administrations to corresponding percentile and age equivalent scores. It was found that automated administration most often yielded lower test scores than standard administration for tests of auditory discrimination and selective attention. Further data at other age groups and subsequent G-F-W normative data adjustment would be necessary to make valid transformations of ASB scores on these tests. It appears that valid transformations could be made on the basis of currently available G-F-W normative data for computerized tests of recognition memory, memory for content, memory for sequence, sound recognition, and sound symbol asssociation.

The small sample size and the limited age range of this study limits the generalizability of these tests results. This study indicates the need for a larger investigation that would extend the age range and further examine the suspect reliabilities of the present study.

The children who worked with "Fred" more than once were always eager to come back again. Other children from the classrooms involved were also concerned with having a turn to work with the computer and

"Fred" became very popular with the children wherever it was located. Although only 120 different children were involved in actual testing sessions with the ASB program, over 200 children had the opportunity to play with the terminal in demonstrations of "Fred"'s programs and games. All interactions were positive and other than boredom which occurred on the lengthy tests, no negative responses were evident.

CHAPTER VIII

APPLICATIONS OF THE COMPUTERIZED AUDITORY SKILLS TEST BATTERY

The software system described in this document was developed with a view towards its subsequent actual implementation into hospital, clinic, and/or school programs. Patient files were designed to be kept individually and both the input and output of the program were formatted in a manner which is familiar to speech language pathologists in hospitals, psychoeducational consultants, special educators and other professional clinicians.

The Auditory Skills Battery can be employed as part of an intake procedure, as an in depth test battery and/or parts of the battery can be utilized for large scale school screening of auditory perceptual skills. The system has the special advantage of being cost effective. A trained volunteer can be used to administer the tests rather than a highly paid professional.

The system also has the added feature of portability. Testing procedures can be carried out at locations removed from a central clinic. Test sites may include satellite clinics of hospitals, various schools, community health clinics and other regional centers. A remote clinic setting only requires a quiet test location (room) and a telephone for the computer hook up.

Application to Learning Disabled Children

During the early development phase of this project the computer terminal was set up at a summer day camp for children with learning disabilities. Thirty-three of these children worked with "Fred" (the computer terminal) through the course of debugging the program and some preliminary data were collected at this time.

These children ranged in age from 7 to 18 years and were diagnosed as having various learning dysfunctions. They were attending special remedial classes and day camp activities. As was the case in the school setting, "Fred" was a successful part of the camp program. All children were eager to participate in the computer testing procedures. Many spent their lunch period and after-program time playing games with the computer.

Goldman, Fristoe and Woodcock (23) report lower scores on their version of the auditory skills battery for learning disabled children than for normals. The data collected for the camp group of learning disabled children indicate similar results. The mean percentile ranks and mean standard scores for the four tests of the ASB that were functioning at the time appear in Table 2. Both the mean of percentile ranks and the mean standard score would be 50 for a normal population. It is evident for these learning disabled children that auditory discrimination, memory for

Table 2. Mean percentile rank and mean standard scores for children with learning disabilities

ASB Test	n	Mean percentile	Mean standard score
Auditory discrimination	33	12.21	34.33
Auditory memory for content	26	29.08	40.62
Auditory memory for sequence	11	9.00	33.18
Sound-symbol association	16	63.25	54.31

content and memory for sequence are below normal skill levels. However, most of these children scored above normal on the test of sound-symbol association. These children were receiving individual remedial programs with specialized drill in a stimulus-response style. It is suggested that this special program sharpened their paired associate learning skills which transferred to their ability to make sound-symbol associations. These test results should be interpreted conservatively in light of the reliability information reported in Chapter VII.

Application to Speech-Language Pathology Clinic

In the latter phases of the project, Speech-Language Pathologists at the Children's Hospital of Eastern Ontario were given a demonstration of the computer-assisted Auditory Skills Battery Test System. At the same time, the usefulness of the computer systems as a tool to access additional information on a patient-client was discussed. A subprogram for computer-assisted testing procedures was set up on a trial basis in the department to determine if therapists would refer internally to such a program and/or would show specific interest in its potential.

The attitude of many of the clinicians to the automated testing was guardedly favorable. Referrals for the automated ASB program were received from within and outside the Department of Speech Pathology. A clinician was anxious to try the automated testing procedures. She claimed that with one child she had tried to assess, standard human administered testing had been unsuccessful. She was hopeful that automated testing would prove to be a valuable alternate modality in this case.

Many clinicians requested specific training in the procedure so that when limited volunteer resources were available the computer-assisted evaluation program could continue.

Referrals to this "trial program" were appropriate. The children referred for testing were generally of school age with either suspected language deficits and/or had been involved in some conventional assessment procedures with a clinician. These clinicians requested additional information in auditory discrimination skill, auditory memory abilities and other auditory perceptual skills.

It is expected that such a program could be permanently established in speech pathology clinics to provide an available resource to speech clinicians. The orientation and scope of the resource would be limited only by the software developed and the capabilities of compatible hardware. As new software is developed in house or becomes available commercially, these computer-assisted clinical service programs will expand.

The size of a given clinical setting should not influence the feasibility of establishing computer-assisted programs. Large multifaceted clinics often function with specialized programs, providing a model for new program introductions. Sole charge clinician departments have an equal need for supplementary clinical resources. The extension of a computer-assisted program to such a clinic could double the service potential available. With the additional development of software programs for activities such as language therapy, parents could be guided through language stimulation activities with their children and function as the parent-therapist enhancing the potential for carry-over of the therapeutic activities into the home environment.

Applications to School

In recent years, there has been an increasing awareness of the importance of early detection and treatment of communication disorders and other learning related problems of school-aged children. This interest in early detection has been the impetus for mass screening in the preschool and early school years. Boards of education have been implementing various early identification programs to detect those children at risk for school related difficulties. Such screening programs are time intensive, and costly in terms of professional resource requirements. Detailed diagnostic batteriers, which are required when children at risk are detected, are even more costly in terms of highly trained human resources. Computerized assessment protocols using less highly trained personnel for administration can be considered for mass screening and also for its potential to profile various learning deficit patterns in children. Such systems could be employed at minimal costs and provide valuable services to both the children in need and the school boards. Early detection facilitates the establishment of timely remedial school programs. The automated ASB is a system which could perform some early screening of

language abilities of children. With available early detection and intervention programs, each child will be able to develop to his/her maximum potential.

Future Directions

It is likely that the LEK 421 system as described in this document will be adapted to run on a microprocessor in addition to or in lieu of the hookup to the mainframe computer via telephone lines. This will eliminate potential time-sharing problems which can decrease the rapidity of test-item presentation and interfere with standardized presentation.

Further tests will be developed for administration on the LEK 421 system, making the system more adaptable and versatile in its application. Subsequent hardware developments will enhance the possibililties of new approaches to testing.

Finally, therapy programs should be considered for use with a system such as the LEK 421. The potential exists for additional telecommunication linkups so that both testing and therapy programs can be administered at remote locations (e.g., Telidon).

CHAPTER IX

CONCLUSIONS

The work reported in this document reflects a three-pronged focus. This includes an attempt to evaluate the efficacy of a newly developed prototype terminal (Lektromedia 421 Portable Learning Terminal); the applicability of this system to the field of language speech pathology through the development of a new software system suitable for clinical use; an evaluation of the reliability and validity of the developed computer-assisted testing program.

Reliability of the Lektromedia 421 PLAT Terminal

Once the Lektromedia 421 PLAT terminal was in clinical use, its component parts were, in general, dependable. It was touched by countless curious children during school and camp placements, and was used repeatedly over extended periods during the evaluation phase.

Portability

The Lektromedia 421 PLAT terminal was designed to be a portable system. Technically it fulfilled this characteristic. It was transported by car within the city of Ottawa to several test sites with only minor difficulties. It also functioned adequately by telephone hook-up after being transported by airplane to Edmonton, Alberta, and to Detroit, Michigan.

Although portable, the system is exceedingly heavy and cumbersome for one person to handle. The problems with weight are compounded should a slight male or a woman be the sole transporter. Some form of "transport dolly" might be considered to enhance the portability characteristic.

Test Development

NATAL 74 and NATAL II were used as the programming language for the software system. Most subtests of the Goldman-Fristoe-Woodcock Auditory Test Skills Battery (23) were successfully adapted for computer-assisted administration. No difficulty is anticipated in creating or adapting other receptive language tests or other psycholinguistic batteries for this system. Should further tests be developed uniquely for computer-assisted presentation, standardization data should be obtained in the automated modality. Attempts to program therapy activities on the system are also recommended for the future.

Utility and Cost Effectiveness

The cost in human resource time to do the computer test battery by standard human administration is approximately 7 h of professional time

and patient contact. Analysis of the data, dictating a patient report, and proofreading frequently exceed an additional 2 h of professional time. The time required by a secretary or medical records typist to produce the report in typed format involves additional time.

The concept of testing via computer by an unpaid trained volunteer was part of the software design. Should the test battery be fully utilized approximately six times per month, with volunteer administrators, the hardware costs will have been covered in the first year of operation, through increased staff productivity. Further cost savings will occur with the subsequent life of the hardware. (Computer CPU charges are not included in this estimate.)

User Response

Clinicians who were exposed to the system through demonstrations and discussions responded very positively in general. Some were anxious to have the automated system implemented immediately into the clinic setting. Clinical referrals from professionals for the ASB testing were generated as soon as the system was made clinically available.

Student testers were also very supportive of the system and responded to a questionnaire reporting that the system was easy to operate, easy to learn and that they believed they were competent testers on the automated task.

The children were universally enthusiastic about interacting with the computerized system. As long as the test items were presented at the optimal rapid speed (high priority run), their interest was maintained.

Applicability

As a result of the experience of this project, the system (hardware and software) is believed to have application for the following: screening of normal children in schools; an evaluation of auditory skills of learning disabled children; evaluation of auditory skills of children referred for a speech-language evaluation in a Speech Pathology Clinic. Future applications would include therapy adaptation in clinical settings and satellite centers.

Reliability and Validity of Testing

Additional investigation in this area is required. Preliminary results obtained indicate adequate test-retest reliability in the automated versions of auditory discrimination testing, selective attention test, recognition memory test, and sound recognition tests. The automated version of the auditory discrimination test and selective attention tests most often yielded lower test scores than standard administration. Test validity in the automated mode as compared to the standard human testing

mode was demonstrated for the following tests: recognition memory test, sound symbol association test, sound recognition test, memory for content test, and memory for sequence test.

The small sample size and the limited age range of this study limits the generalizability of these results. Further investigation and additional standardization studies are required.

Summary

The system described in this document provides computer-assisted testing of selected language abilities, test data analysis, and report production. It has been shown to be a viable, valuable and cost efficient approach. Future developments in hardware and software will continue to further enhance the application of technology to health and educational settings. The hardware available in this study and the software system possess an exciting potential for improving professional service delivery patterns and increasing public access to much needed clinical programs.

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APPENDIX 1

MAINTENANCE

Hardware

Printer

The Silent 700 Portable Data Terminal uses rolls of thermal printing paper (Texas Instruments Part No. 972603). A new paper roll should be added when the colour coded strip indicates the end of the roll. The paper door is located behind the print head and directions for changing paper rolls appear on the underside of this door.

According to maintenance instructions in the Silent 700 Manual, the print head should be cleaned each time a new roll of thermal paper is loaded into the terminal as follows:

> Wet a sheet of good quality bond paper with a two inch strip of denatured alcohol; insert this sheet into the empty paper chute as if loading a new paper roll; print five lines on the bond paper, across the wet alcohol strip using the REPT key to accelerate the printing rate; advance the paper to a dry area and print two more lines; then advance the band paper out of the paper chute and reload with thermal printing paper.

Audio/Controller Unit

The audio portion of this unit requires cleaning of the tape head on a regular basis. Good quality magnetic tape head cleaner (such as Miller-Stephenson MS-200) should be sprayed onto a cotton swab. The swab is then rubbed over all surfaces of the tape player that come in contact with the audio tape. It is recommended that this be done once a day.

Touch Panel

The front surface of the touch panel requires regular cleaning with window cleaning fluid to keep it free from dust and grease. Any hard-to-remove marks may be cleaned off with denatured alcohol. It is recommended that the touch panel be cleaned once a week.

Software

The ASB program is in someways self maintaining. For example, CONTINUE Mode, which stores a child's incomplete test results for future completion of the test, will delete these records after two months, so that a large file of useless incomplete results is not taking up a large portion of storage space in the program.

Regular maintenance of the registration file should be conducted to ensure that invalid data used for test or demonstration purposes are removed from the data base of this program. This is achieved in MAINTENANCE Mode of the ASB program. The Delete option requires knowledge of a delete password.

APPENDIX II

TROUBLE SHOOTING

Functions

1. [CTRLC] HELP MODE of the ASB program explains that whenever there is a problem in the use of the program a control C command by the user will interrupt the program and terminate NATAL. This is achieved by typing the CTRL and the C key at the same item. On occasion more than one control C may be required. The computer will return the (.) prompt as a response.

2. [RESET] If a problem appears to be related to the hardware rather than the program a terminal reset procedure may correct it. To reset the terminal put the audio/controller unit in local, by switching the ON LINE/LOCAL switch, located at the back face of the audio/controller unit, to the local position. This acts to temporarily disconnect the terminal from the computer. Next press the reset button, the small red button located above the ON LINE/LOCAL switch. When the reset button is pressed the slide projector will switch on and off and the slide tray will return to the 0 position. The touch panel beep will also sound. Move the ON LINE/LOCAL switch back to the ON LINE position and the terminal will be reset.

3. LOCAL COMMANDS The components of the LEK 421 PLAT terminal will respond to commands typed via the keyboard when the terminal is switched to local mode. Local mode is achieved by switching the ON LINE/LOCAL switch located at the back face of the audio/controller unit to the local position. Local commands function to affect the slide projector, audio tape player or touch panel as outlined below. Following a local command the ON/LINE/LOCAL switch must be switched to ON LINE to re-establish communication with the computer.

Function	Command	Explanation
Slides: 1. To move the slide tray 0 position to the arrow mark for removal and to turn off the projector light	CTRL A 0002 O CTRL	The projector is set at the 0 position and turned off

2. To present a particular slide on the screen	CTRL A 0002 n_1n_2 CTRL	Where n_1n_2 refers to any slide number from 1 to 80. The projector is turned on and the slide tray is moved to the appropriate position
Audio:		
1. To index a tape	CTRL A 0004 S CTRL	The audio cassette unit will read the tape indices in preparation for presentation of audio messages
2. To play an audio message	CTRL A 0004 $n_1n_2n_3$ CTRL	Where $n_1n_2n_3$ refers to any audio number from 1 to 199. The audio message is accessed and played
Touch Panel:		
1. To enable the touch panel	CTRL A 0003 CTRL	The touch panel screen is enabled and now sensitive to touch. If touched while the terminal is still in local mode, the coordinates of the touch will be printed as 0003 X1X2Y1Y2, where X1X2 refers to the horizontal coordinates which range from 0 to 39 and Y1Y2 refers to the vertical coordinates which range from 0 to 31

[NOTE: ON Completion of a local command, move audit/controller ON LINE/LOCAL switch to ON LINE.]

The trouble shooting chart which follows outlines some difficulties which have occurred and the solution to each problem with use of the procedures of CTRL C, RESET and local commands.

Symptons	Explanations	Problem Solving Procedure
BAD ADDR TRACK appears on the printer. Audio message is not played	The appropriate address for the Audio messages to be has not been located	1. [CTRL C] to get out of NATAL 2. Remove tape 3. Clean tape head as outlined in Appendix 1 4. Re-insert tape 5. To re-access the NATAL language after the (.) prompt type R NATAL 6. Once in the ASB program CONTINUE MODE may be used to complete a test which may have been interrupted by the bad address track
Slide and audio message does not correspond	Slide tray has become misaligned in the projector	1. [CTRL C] to get out of NATAL 2. Follow [RESET] instructions: (a) If slide tray 0 position is now at the arrow mark on the projector: Re-access NATAL after (.) prompt by typing R NATAL. Use CONTINUE MODE if testing has been interrupted. (b) If slide position 0 is not in the arrow mark use the [LOCAL COMMANDS] as follows: Considering that the projector is now set up to function as if the slide tray was in the 0 position, determine the slide number necessary to call to place the slide tray 0 position at the arrow mark on the projector. Call this slide number using [LOCAL COMMAND]

		as outlined above. The slide tray 0 should now correspond with the arrow mark on the projector. Remove the slide tray. Without the slide tray in place, use [LOCAL COMMANDS] to set the projector to the 0 position. Re-insert the slide tray. The 0 slide position will correspond to the arrow mark. Re-access NATAL after the (.) prompt by typing R NATAL. Use the CONTINUE MODE if testing has been interrupted
Touch panel does not respond to touch with a beep, touch panel light is not on and the program is stopped	Touch panel has not been enable	1. Use [LOCAL COMMANDS] to enable the touch panel 2. Be sure to move the ON LINE/LOCAL switch back to ON LINE position before touching the touch panel 3. The program will progress normally
The occurrence of many invalid or incorrect touch responses in a row	The projected slide image is misaligned on the touch panel screen	1. [CTRL C] to get out of NATAL 2. Using [LOCAL COMMANDS] call any slide to be projected to the screen 3. Adjust the height of the screen or the slide projector so that the slide image is exactly centered on the screen 4. Re-access NATAL after the (.) prompt by typing R NATAL 5. Re-test in TESTING MODE Do not use CONTINUE MODE as previous responses are invalid

If the LEK 421 PLAT is connected to a larger system via telephone, the following symptoms may occur		
Inappropriate characters appear on the printer. Small green light on printer keyboard may not be on	Interference on the telephone line or complete loss of the connection	Attempt to progress in the program normally. If the program does not progress: [CTRL C] to determine if interaction with computer is possible. a. If the (.) prompt is returned on the printer, re-access NATAL and progress with the program. b. If the (.) prompt is not returned in response [CTRL C]: Hang up telephone. [RESET] the terminal. Redial the telephone and place the receiver in the acoustic coupler. [CTRL C]. Log on again if requested via the printer. Re-access NATAL after the (.) prompt by typing R NATAL
Printer does not show what is typed on the keyboard	Printer is not echoing	1. [CTRL C] 2. At the (.) prompt type SET TTY ECHO 3. Re-access NATAL after the (.) prompt by typing R NATAL 4. Proceed with the program

APPENDIX III
EXAMPLES OF DOCUMENTATION PREPARATION

AUDITORY DISCRIMINATION PART A - TRAINING SECTION

General Design

The training section of this assessment consists of 16 slides containing four pictures each. Two items are presented via audio tape for each slide. The audio message instructs the child to point to the picture that represents a particular word. If the child touches the correct picture, the next item is presented. If the child chooses the incorrect picture, the message "That's not S, try again", is played with S being the stimulus word. This is the feedback message and occurs on the tape immediately following the stimulus message. i.e.
"Point to bird" --- "That's not bird. Try again" --- "Point to star"

stimulus message feedback message

"That's not star. Try again" --- Point.....

The feedback message is played only if the child makes an incorrect response, and it is played after every incorrect response until the child chooses the correct picture. The next audio stimulus message is presented only after the child has made the correct choice on the previous item. If the child makes a correct response initially, the feedback message is omitted and the next stimulus message is presented.

All 36 audio messages are presented in this manner. Any items on which the child made an incorrect response initially are recorded, and after all 36 items are presented the incorrect items are administered again in the same manner as the first training trial. Again, any items on which the child made an incorrect response are recorded and presented again, in a third training trial. Any items for which the child is unable to choose the correct picture, with the first response on the third trial, are then printed out on the printer with a message to the tester to teach these items. The slides are then presented under tester central with input from the keyboard. Detailed instructions are presented to the tester via the printer.

The Auditory Discrimination Results Output will indicate any problems in this training section.

Step	Audio	Printer	Slide Screen
2a	Hi. We're going to play a game together. You will see some pictures on the screen. When you hear a word, you put your finger on the picture of that word. Put your finger on the little man.		Little Man
2b If response correct go to step 4; Otherwise, go to step 3.	Put your finger on lawn.	Lawn	Face / Lawn Tack / Sink
3 Step 3 is presented until the child makes the correct response. Then to step 4.	That is not lawn. Try again.	Lawn	Same
4	Put your finger on sink.	Sink	Same
5	That's not sink. Try again.	Sink	Same
6	Put your finger on tag.	Tag	Think / Bee Tag / Vase
7	That's not tag. Try again.	Tag	Same
8	Put your finger on bee.	Bee	Same
9	That's not bee. Try again.	Bee	Same
10	Point to path.	Path	Path / Sip Ache / Knee

Step	Audio	Printer	Slide Screen
Step 1		DIAGNOSTIC AUDITORY DISCRIMINATION <u>Training Section</u> Presentation of the training section is the first step in administering the Auditory Discrimination Test. Sixteen slides and four pictures per slide are shown. The child is asked, via the audio tape, to touch two different pictures on each slide. <u>Press 1 to begin the training</u> If he touches the incorrect picture the tape will inform him and ask him to try again. A new item is presented only after he touches the correct item picture for the last item. Any items that were incorrect are presented again. After three presentations, the tester will be asked to teach the incorrect items to the child. Detailed instructions will be given. The purpose of the training section is to assure that the child is able to identify all the pictures that will subsequently appear in the testing section. Adjust the volume of the tape player so the child hears the audio messages at a "comfortably loud" level. (Include instructions to the tester concerning loading the tape or slide tray.)	

Recording of Responses

The child's response to each audio stimulus should be recorded. Also of interest is the number of trials an item was presented (maximum of 4). No latency data are required for the training section.

Output

A Option to have printed out each item presented and child's response for all children or one individually.

B For each individual child:

1. Items not learned by third trial and explained by the tester

   No. =

   List them

2. Items not learned

   No. =

   List them

   The interpretation of test results should take this into account.

POOR

QUALITY

ORIGINAL